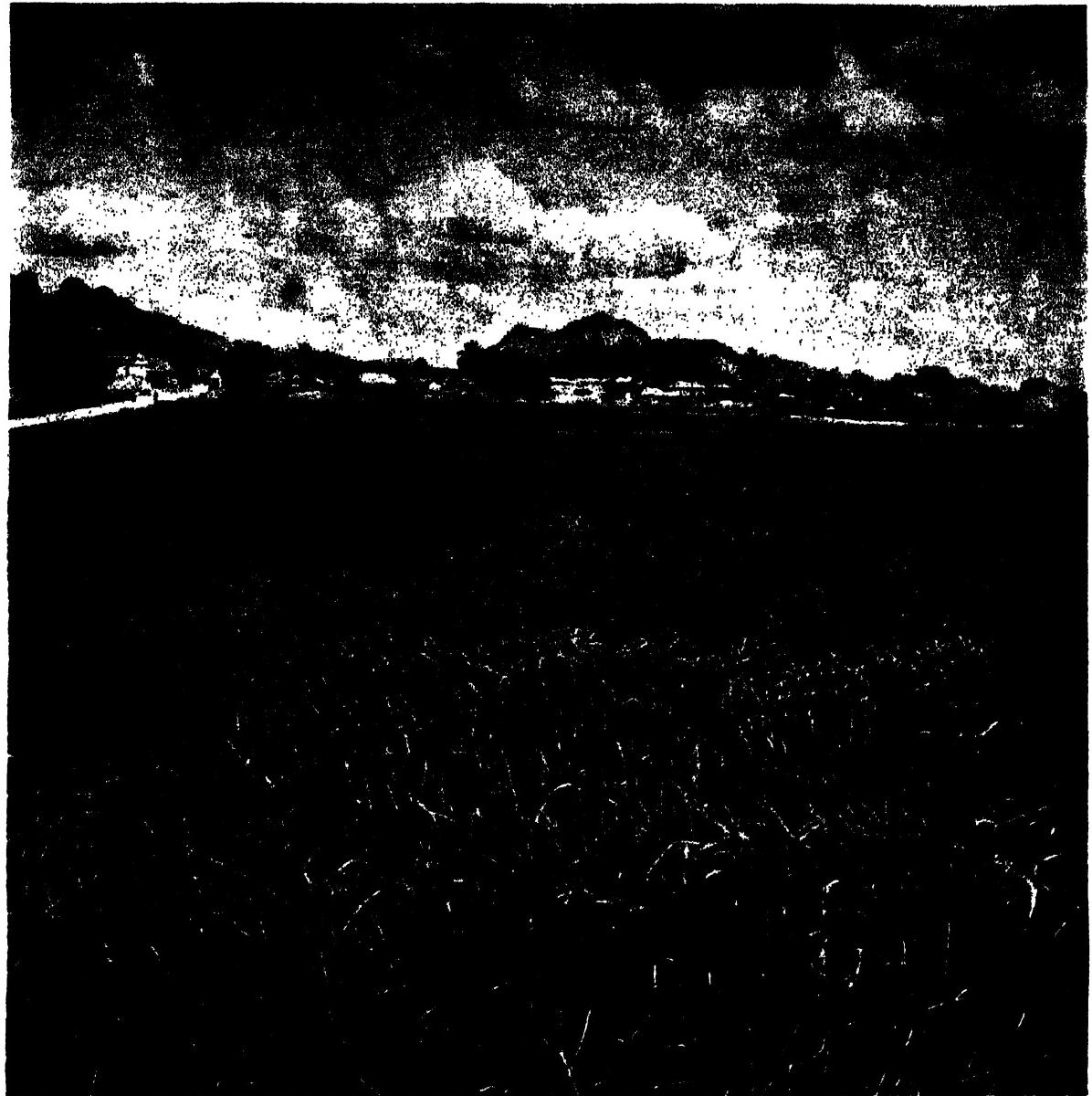


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**THE
WEALTH OF INDIA**

Pl. I



Indian Coun. Agric. Res., New Delhi

ORYZA SATIVA — PADDY FIELD READY FOR HARVEST

THE WEALTH OF INDIA

A DICTIONARY OF
INDIAN RAW MATERIALS
AND INDUSTRIAL PRODUCTS

RAW MATERIALS
VOL. VII : N - Pe



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INTRODUCTION

This is the seventh volume in the series of Wealth of India--Raw Materials and contains 301 entries—294 on plant species, 4 on animals and animal products and 3 on minerals. It follows mainly the pattern of previous volumes and covers some important topics as *Nicotiana*, *Oryza*, *Papaver* and *Pennisetum* among plants, *Oysters* among animals and *Petroleum* among minerals. In the compilation of some of these articles considerable difficulties were experienced, particularly in the case of those on *Oryza* and *Petroleum*. The volume of work surveyed in the case of *Oryza* has been rapidly increasing and new and varying opinions are being expressed on some of the important aspects, e.g. its taxonomy, genetics, physiology and agronomy. In the case of *Petroleum*, the country has been developing its resources so rapidly that the picture has been changing from one part of the year to the other. In order to make these articles as comprehensive as possible, enquiries have been made from different sources and also specialists in the field have been consulted. As in the case of previous volumes, every effort has been made to give all available information after proper scrutiny, up to the time of sending the manuscripts to the press.

The following contributions have been received from external sources, and have been specially valuable in preparing the respective articles: *Oryza (Cultivation of Rice in India)* by Dr. K. Ramiah, Retired Director, Central Rice Research Institute, Cuttack and former Consultant in Rice, FAO; *Taxonomy of Oryza species* by Shri S. Sampath, Botanist, Central Rice Research Institute, Cuttack; *Chemical Composition of Rice and Rice Products* by the Central Food Technological Research Institute, Mysore; *Ocimum* by Dr. G. N. Gupta, Harcourt Butler Technological Research Institute, Kanpur; *Oysters* by Dr. K. Veerabhadra Rao, Central Marine Fisheries Research Institute, Mandapam; and *Parasitic Worms* by Dr. G. S. Thapar, Retired Professor of Helminthology, Lucknow. In the case of the article on *Nicotiana*, the monograph published by the Indian Central Tobacco Committee has been used as the basis, while the article on *Petroleum* was scrutinized and approved by the Ministry of Petroleum and Chemicals. To all these contributors and other specialists from whom information has been received, we are greatly indebted. We are also grateful to Prof. A. F. Hill (Botanical Museum, Harvard University, U.S.A.), Rev. H. Santapau (Director, Botanical Survey, Calcutta), Shri M. B. Raizada (Retired Botanist, Forest Research Institute, Dehra Dun) and Dr. S. K. Mukherjee (Keeper, Central National Herbarium, Calcutta) for help in checking the botanical nomenclature; to the President, Forest Research Institute, Dehra Dun; Director, Indian Agricultural Research Institute, New Delhi; Director, Central Tobacco Research Institute, Rajahmundry; Director of Arts, Indian Council of Agricultural Research, New Delhi; Superintendent, Lalbagh Botanic Garden, Bangalore and various other specialists and institutions for supply of illustrations and other data. Our sincere gratitude is also due to the members of the Editorial Committee for their guidance, especially to Dr. S. Husain Zaheer, Director-General, for his kind interest and inspiration in the execution of this work. The articles on Animals & Animal Products have been compiled under the supervision of Dr. Baini Prasad and we are much indebted to him. Grateful appreciation is also expressed to all the staff engaged in this national effort, for their unstinted labour and loyal cooperation.

We are keenly aware of the need for completing the compilation of the remaining volumes as expeditiously as possible. The nature of the undertaking, involving as it does exhaustive scrutiny of the ever increasing bulk of scientific literature, critical appraisal of the collected data derived from various sources and refereeing the completed articles to specialists, take time and retard the speed of the compilation. However, steps are being taken to complete the remaining volumes in the shortest time possible. Suggestions for improvement will be gratefully received and made use of in subsequent volumes.

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<i>Emp. J. exp. Agric.</i>	..	<i>Empire Journal of Experimental Agriculture, Oxford.</i>
<i>Euphytica</i>	..	<i>Euphytica, Wageningen.</i>
<i>Evolution</i>	..	<i>Evolution, International Journal of Organic Evolution, Lancaster, Pa.</i>
<i>FAO nutr. Stud.</i>	..	<i>FAO Nutritional Studies, Rome.</i>
<i>Farm Bull. Indian Coun. agric. Res.</i>	..	<i>Farm Bulletin, Indian Council of Agricultural Research, New Delhi.</i>
<i>Farmer</i>	..	<i>Farmer, Bombay.</i>
<i>Fertil. News</i>	..	<i>Fertiliser News, New Delhi.</i>
<i>Fieldiana, Bot.</i>	..	<i>Fieldiana: Botany, Chicago.</i>
<i>Fmg in S. Afr.</i>	..	<i>Farming in South Africa, Pretoria.</i>
<i>Fmrs' Bull. U.S. Dep. Agric.</i>	..	<i>Farmers' Bulletin, United States Department of Agriculture, Washington.</i>
<i>Food Res.</i>	..	<i>Food Research, Champaign, Ill.</i>
<i>Food Sci.</i>	..	<i>Food Science, Mysore.</i>
<i>Food Technol., Champaign</i>	..	<i>Food Technology, Champaign, Ill.</i>
<i>For. Abstr.</i>	..	<i>Forestry Abstracts, Commonwealth Agriculture Bureaux, Farnham Royal.</i>
<i>For. Res. India</i>	..	<i>Forest Research in India (and Burma), Calcutta.</i>
<i>Gdn J., N.Y.</i>	..	<i>The Garden Journal of the New York Botanical Garden, New York.</i>
<i>Gdns' Bull.</i>	..	<i>Gardens' Bulletin, Straits Settlements, Singapore.</i>
<i>Handb. Inst. Nutr. Philipp.</i>	..	<i>Handbook, Institute of Nutrition, Philippines, Manila.</i>
<i>Helv. chim. acta</i>	..	<i>Helvetica chimica acta, Basel, Genf.</i>
<i>Hlth Bull.</i>	..	<i>Health Bulletin, New Delhi.</i>
<i>Hort. Abstr.</i>	..	<i>Horticultural Abstracts, East Malling.</i>
<i>Indian Agriculturist</i>	..	<i>Indian Agriculturist, Calcutta.</i>

<i>Indian Ecol.</i>	..	Indian Ecologist, Bombay.
<i>Indian Fd Packer</i>	..	Indian Food Packer, Bombay.
<i>Indian Fmg</i>	..	Indian Farming, New Delhi.
<i>Indian Fmg, N.S.</i>	..	Indian Farming, New Series, New Delhi.
<i>Indian For.</i>	..	Indian Forester, Dehra Dun.
<i>Indian For. Bull., N.S.</i>	..	Indian Forest Bulletin, New Series, Dehra Dun.
<i>Indian For. Leafl.</i>	..	Indian Forest Leaflets, Dehra Dun.
<i>Indian For. Mem., For. Bot. Ser.</i>	..	Indian Forest Memoirs, Forest Botany Series, Calcutta.
<i>Indian For. Rec., N.S., Bot.</i>	..	Indian Forest Records, New Series, Botany, Dehra Dun.
<i>Indian For. Rec., N.S., Chem.</i>	..	Indian Forest Records, New Series, Chemistry, Dehra Dun.
<i>Indian For. Rec., N.S., Chem. & Minor For. Prod.</i>	..	Indian Forest Records, New Series, Chemistry and Minor Forest Products, Dehra Dun.
<i>Indian For. Rec., N.S., Mycol.</i>	..	Indian Forest Records, New Series, Mycology, Dehra Dun.
<i>Indian For. Rec., N.S., Timb. Mech.</i>	..	Indian Forest Records, New Series, Timber Mechanics, Dehra Dun.
<i>Indian For. Rec., N.S., Util.</i>	..	Indian Forest Records, New Series, Utilization, Dehra Dun.
<i>Indian Hort.</i>	..	Indian Horticulture, New Delhi.
<i>Indian hort. Abstr.</i>	..	Indian Horticultural Abstracts, New Delhi.
<i>Indian J. agric. Sci.</i>	..	Indian Journal of Agricultural Science, New Delhi.
<i>Indian J. Agron.</i>	..	Indian Journal of Agronomy, New Delhi.
<i>Indian J. appl. Chem.</i>	..	Indian Journal of Applied Chemistry, Calcutta.
<i>Indian J. Dairy Sci.</i>	..	Indian Journal of Dairy Science, Bangalore.
<i>Indian J. Ent.</i>	..	Indian Journal of Entomology, New Delhi.
<i>Indian J. Fish.</i>	..	Indian Journal of Fisheries, Delhi.
<i>Indian J. Genet.</i>	..	Indian Journal of Genetics and Plant Breeding, New Delhi.
<i>Indian J. Helminth.</i>	..	Indian Journal of Helminthology, Lucknow.
<i>Indian J. Hort.</i>	..	Indian Journal of Horticulture, New Delhi.
<i>Indian J. Malariaiol.</i>	..	Indian Journal of Malariaiology, Delhi.
<i>Indian J. med. Res.</i>	..	Indian Journal of Medical Research, Calcutta.
<i>Indian J. med. Sci.</i>	..	Indian Journal of Medical Sciences, Bombay.
<i>Indian J. Pharm.</i>	..	Indian Journal of Pharmacy, Bombay.
<i>Indian J. Physiol.</i>	..	Indian Journal of Physiology and Allied Sciences, Calcutta.
<i>Indian J. vet. Sci.</i>	..	Indian Journal of Veterinary Science and Animal Husbandry, New Delhi.
<i>Indian med. Gaz.</i>	..	Indian Medical Gazette, Calcutta.
<i>Indian med. Res. Mem.</i>	..	Indian Medical Research Memoirs, Calcutta.
<i>Indian Miner.</i>	..	Indian Minerals, Calcutta.
<i>Indian Miner. Ind.</i>	..	Indian Mineral Industries, Bombay.
<i>Indian Miner. Yearb.</i>	..	Indian Minerals Yearbook, Nagpur.
<i>Indian Min. J.</i>	..	Indian Mining Journal, Calcutta.
<i>Indian Oilseeds J.</i>	..	Indian Oilseeds Journal, Hyderabad.
<i>Indian Oil & Soap J.</i>	..	Indian Oil and Soap Journal, Calcutta.
<i>Indian Perfum.</i>	..	Indian Perfumer, Kanpur.
<i>Indian Phytopath.</i>	..	Indian Phytopathology, New Delhi.
<i>Indian Pulp Pap.</i>	..	Indian Pulp and Paper, Calcutta.
<i>Indian Soap J.</i>	..	Indian Soap Journal, Calcutta.
<i>Indian Tob.</i>	..	Indian Tobacco, Madras.
<i>Indian vet. J.</i>	..	Indian Veterinary Journal, Madras.
<i>Indian zool. Mem.</i>	..	Indian Zoological Memoirs, Lucknow.
<i>Industr. Engng Chem.</i>	..	Industrial and Engineering Chemistry, Easton, Pa.
<i>Industry, Calcutta</i>	..	Industry, Calcutta.
<i>Int. Rev. Agric.</i>	..	International Review of Agriculture, Rome.
<i>Int. Rice Comm. News Lett.</i>	..	International Rice Commission News Letter, Bangkok.
<i>J. agric. Ed Chem.</i>	..	Journal of Agricultural and Food Chemistry, Easton, Pa.
<i>J. agric. Res.</i>	..	Journal of Agricultural Research, Washington.
<i>J. agric. Sci.</i>	..	Journal of Agricultural Science, Cambridge.
<i>J. Agric. trop.</i>	..	Journal D' Agriculture tropicale et de Botanique Appliquee, Paris.
<i>J. Amer. chem. Soc.</i>	..	Journal of the American Chemical Society, Easton, Pa.
<i>J. Amer. Oil Chem. Soc.</i>	..	Journal of the American Oil Chemists' Society, Chicago.
<i>J. Amer. pharm. Ass., sci. Edn</i>	..	Journal of the American Pharmaceutical Association, Scientific Edition, Columbus.
<i>J. Arnold Arbor.</i>	..	Journal of the Arnold Arboretum, Lancaster, Pa.
<i>J. Asiat. Soc. Beng., N.S.</i>	..	Journal and Proceedings of the Asiatic Society of Bengal, New Series, Calcutta.
<i>J. Aust. Inst. agric. Sci.</i>	..	Journal of Australian Institute of Agricultural Science, Sydney.
<i>J. Banaras Hindu Univ.</i>	..	Journal of Banaras Hindu University, Varanasi.

<i>J. biol. Chem.</i>	..	Journal of Biological Chemistry. Baltimore.
<i>J. biol. Sci.</i>	..	Journal of Biological Sciences. Bombay.
<i>J. Bombay nat. Hist. Soc.</i>	..	Journal of the Bombay Natural History Society. Bombay.
<i>J. chem. Soc.</i>	..	Journal of the Chemical Society. London.
<i>J. Chem. U.A.R.</i>	..	Journal of Chemistry of the United Arab Republic. Cairo.
<i>J. comp. Path.</i>	..	Journal of Comparative Pathology and Therapeutics. Edinburgh, London, Croydon.
<i>J. Dep. Agric. S. Aust.</i>	..	Journal of the Department of Agriculture of South Australia. Adelaide.
<i>J. Fd. Sci.</i>	..	Journal of Food Science. Champaign, Ill.
<i>J. Genet.</i>	..	Journal of Genetics. Cambridge.
<i>J. Gujarat Res. Soc.</i>	..	Journal of the Gujarat Research Society. Bombay.
<i>J. Helminth.</i>	..	Journal of Helminthology. London.
<i>J. Hered.</i>	..	Journal of Heredity. Washington.
<i>J. Ind. & Tr.</i>	..	Journal of Industry and Trade. New Delhi.
<i>J. Indian bot. Soc.</i>	..	Journal of the Indian Botanical Society. Madras.
<i>J. Indian chem. Soc.</i>	..	Journal of the Indian Chemical Society. Calcutta.
<i>J. Indian chem. Soc., industr. Edn</i>	..	Journal of the Indian Chemical Society. Industrial and News Edition. Calcutta.
<i>J. Indian Inst. Sci.</i>	..	Journal of the Indian Institute of Science. Bangalore.
<i>J. Indian med. Ass.</i>	..	Journal of the Indian Medical Association. Calcutta.
<i>J. Indian Soc. Soil Sci.</i>	..	Journal of the Indian Society of Soil Science. New Delhi.
<i>J. Instn Chem. India</i>	..	Journal and Proceedings of the Institution of Chemists, India. Calcutta.
<i>J. Linn. Soc., Bot.</i>	..	Journal of the Linnean Society. Botany. London.
<i>J. Malar. Inst. India</i>	..	Journal of the Malaria Institute of India. Calcutta.
<i>J. Nutr.</i>	..	Journal of Nutrition. Philadelphia, Pa.
<i>J.N.Y. bot. Gdn</i>	..	Journal of the New York Botanical Garden. New York.
<i>J. Oil Col. Chem. Ass.</i>	..	Journal of the Oil and Colour Chemists' Association. Slough.
<i>J. org. Chem.</i>	..	Journal of Organic Chemistry. Easton, Pa.
<i>J. Osmania Univ.</i>	..	Journal of Osmania University. Hyderabad.
<i>J. Parasit.</i>	..	Journal of Parasitology. Lancaster, Pa.
<i>J. Pharm., Lond.</i>	..	Journal of Pharmacy and Pharmacology. London.
<i>J. pharm. Sci. U.A.R.</i>	..	Journal of Pharmaceutical Sciences of the United Arab Republic. Cairo.
<i>J. Sci. Club, Calcutta</i>	..	Journal of the Science Club. Calcutta.
<i>J. Sci. Fd Agric.</i>	..	Journal of the Science of Food and Agriculture. London.
<i>J. sci. industr. Res.</i>	..	Journal of Scientific and Industrial Research. New Delhi.
<i>J. sci. Res. Banaras Hindu Univ.</i>	..	Journal of Scientific Research of the Banaras Hindu University. Varanasi.
<i>J. sci. Res. Indonesia</i>	..	Journal for Scientific Research in Indonesia. Djakarta.
<i>J. Soc. chem. Ind., Lond.</i>	..	Journal of the Society of Chemical Industry. London.
<i>J. Timb. Dryers' & Pres. Ass. India</i>	..	Journal of The Timber Dryers' and Preservers' Association of India. Dehra Dun.
<i>J. Univ. Bombay</i>	..	Journal of the University of Bombay. Bombay.
<i>J. Univ. Bombay, N.S.</i>	..	Journal of the University of Bombay. New Series. Bombay.
<i>Jap. J. Bot.</i>	..	Japanese Journal of Botany. Tokyo.
<i>Jap. J. Breed.</i>	..	Japanese Journal of Breeding. Tokyo.
<i>Jt Publ. imp. agric. Bur.</i>	..	Joint Publications, Imperial (Commonwealth) Agricultural Bureau. Aberystwyth.
<i>Kew Bull.</i>	..	Kew Bulletin. Royal Botanic Gardens. Kew.
<i>Kew Bull. Addl Ser.</i>	..	Kew Bulletin. Additional Series. Royal Botanic Gardens. Kew.
<i>Leaflet. Dep. Agric. Bombay</i>	..	Leaflet. Department of Agriculture, Bombay. Bombay.
<i>Leaflet. U.S. Dep. Agric.</i>	..	Leaflet. United States Department of Agriculture. Washington.
<i>Lloydia</i>	..	Lloydia. Ohio.
<i>Lucknow Univ. Stud.</i>	..	Lucknow University Studies. Faculty of Science. Lucknow.
<i>Madras agric. J.</i>	..	Madras Agricultural Journal. Coimbatore.
<i>Madras Fish. Bull.</i>	..	Madras Fisheries' Bureau Department Bulletin. Madras.
<i>Malay. agric. J.</i>	..	Malayan Agricultural Journal. Kuala Lumpur.
<i>Mem. Cornell Univ. agric. Exp. Sta.</i>	..	Memoirs of the Cornell University Agricultural Experiment Station. Ithaca, New York.
<i>Mem. Dep. Agric. India, Bot.</i>	..	Memoirs of the Department of Agriculture in India. Botanical Series. Pusa.
<i>Mem. Dep. Agric. India, Chem.</i>	..	Memoirs of the Department of Agriculture in India. Chemical Series. Pusa.
<i>Mem. Dep. Agric. Madras</i>	..	Memoirs of the Department of Agriculture, Madras. Madras.
<i>Mem. geol. Surv. India</i>	..	Memoirs of the Geological Survey of India. Calcutta.
<i>Mem. Indian Mus.</i>	..	Memoirs of the Indian Museum. Calcutta.
<i>Miner. Surv. Rep., Jammu & Kashmir</i>	..	Mineral Survey Report. Jammu & Kashmir Government. Srinagar.
<i>Misc. Bull. Indian Coun. agric. Res.</i>	..	Miscellaneous Bulletin. Indian Council of Agricultural Research. New Delhi.
<i>Mysore agric. J.</i>	..	Mysore Agricultural Journal. Bangalore.
<i>Nagpur agric. Coll. Mag.</i>	..	Nagpur Agricultural College Magazine. Nagpur.

<i>Nature, Lond.</i>	..	<i>Nature, London.</i>
<i>Nature Mag.</i>	..	<i>Nature Magazine, Baltimore.</i>
<i>Naturwissenschaften</i>	..	<i>Naturwissenschaften, Berlin.</i>
<i>New Phytol.</i>	..	<i>New Phytologist, Cambridge.</i>
<i>Nutr. Abstr. Rev.</i>	..	<i>Nutrition Abstracts and Reviews, Aberdeen.</i>
<i>Oil Commentary</i>	..	<i>Oil Commentary, New Delhi.</i>
<i>Oils & Oilseeds J.</i>	..	<i>Oils & Oilseeds Journal, Bombay.</i>
<i>Oil Statist.</i>	..	<i>Oil Statistics, Petroleum Information Service, New Delhi.</i>
<i>ONGC News Lett.</i>	..	<i>ONGC News Letter, Dehra Dun.</i>
<i>ONGC Rep.</i>	..	<i>ONGC Reporter, Dehra Dun.</i>
<i>Oryza</i>	..	<i>Oryza, Cuttack.</i>
<i>Pacif. Sci.</i>	..	<i>Pacific Science, Honolulu.</i>
<i>Paintindia</i>	..	<i>Paintindia, Bombay.</i>
<i>Pakist. J. For.</i>	..	<i>Pakistan Journal of Forestry, Abbottabad.</i>
<i>Pakist. J. Sci.</i>	..	<i>Pakistan Journal of Science, Lahore.</i>
<i>Pakist. J. sci. industr. Res.</i>	..	<i>Pakistan Journal of Scientific & Industrial Research, Karachi.</i>
<i>Parasitology</i>	..	<i>Parasitology, Cambridge.</i>
<i>Perfum. essent. Oil Rec.</i>	..	<i>Perfumery and Essential Oil Record, London.</i>
<i>Pharm. Acta Helvet.</i>	..	<i>Pharmaceutica Acta Helveticae, Zurich.</i>
<i>Pharm. J.</i>	..	<i>Pharmaceutical Journal and Pharmacist, London.</i>
<i>Philipp. agric. Rev.</i>	..	<i>Philippine Agricultural Review, Manila.</i>
<i>Philipp. J. Sci.</i>	..	<i>Philippine Journal of Science, Manila.</i>
<i>Phyton</i>	..	<i>Phyton, Annales rei botanicae, Horn, N.O.</i>
<i>Phytopathology</i>	..	<i>Phytopathology, Lancaster, Pa.</i>
<i>Phytopath. Z.</i>	..	<i>Phytopathologische Zeitschrift, Berlin.</i>
<i>Plant Breed. Abstr.</i>	..	<i>Plant Breeding Abstracts, Cambridge.</i>
<i>Poona agric. Coll. Mag.</i>	..	<i>Poona Agricultural College Magazine, Poona.</i>
<i>Poult. Sci.</i>	..	<i>Poultry Science, Ithaca, N.Y.</i>
<i>Proc. Indian Acad. Sci.</i>	..	<i>Proceedings of the Indian Academy of Sciences, Bangalore.</i>
<i>Proc. Indian Sci. Congr.</i>	..	<i>Proceedings of the Indian Science Congress, Calcutta.</i>
<i>Proc. nat. Acad. Sci. India</i>	..	<i>Proceedings of the National Academy of Sciences, India, Allahabad.</i>
<i>Proc. nat. Inst. Sci. India</i>	..	<i>Proceedings of the National Institute of Sciences of India, New Delhi.</i>
<i>Proc. roy. Soc. Edinb.</i>	..	<i>Proceedings of the Royal Society of Edinburgh, Edinburgh.</i>
<i>Proc. zool. Soc. Lond.</i>	..	<i>Proceedings of the Zoological Society of London, London.</i>
<i>Prod. Yearb. FAO</i>	..	<i>Production Yearbook, FAO Rome.</i>
<i>Punjab Fmr</i>	..	<i>Punjab Farmer, Simla.</i>
<i>Punjab Fr. J.</i>	..	<i>Punjab Fruit Journal, Lahore.</i>
<i>Qd agric. J.</i>	..	<i>Queensland Agricultural Journal, Brisbane.</i>
<i>Qualit. Plant. Mat. Veg.</i>	..	<i>Qualitas Plantarum et Materiae Vegetabilis, The Hague.</i>
<i>Quart. J. Crude Drug Res.</i>	..	<i>Quarterly Journal of Crude Drug Research, Amsterdam.</i>
<i>Quart. Rev. Biol.</i>	..	<i>Quarterly Review of Biology, Baltimore.</i>
<i>Rec. bot. Surv. India</i>	..	<i>Records of the Botanical Survey of India, Calcutta.</i>
<i>Rec. geol. Surv. India</i>	..	<i>Records of the Geological Survey of India, Calcutta.</i>
<i>Rec. Indian Mus.</i>	..	<i>Records of the Indian Museum, Delhi.</i>
<i>Reinwardtia</i>	..	<i>Reinwardtia, Kebun Raya.</i>
<i>Rep. Dep. Nutr. Govt. Bombay</i>	..	<i>Report, Department of Nutrition, Govt. of Bombay, Bombay.</i>
<i>Rep. essent. Oils Schimmel</i>	..	<i>Annual Report on Essential Oils, Aromatic Chemicals and Related Materials, Schimmel & Co., New York.</i>
<i>Rep. trop. Prod. Inst., Lond.</i>	..	<i>Report, Tropical Products Institute, London.</i>
<i>Rep. vet. Res. S. Afr.</i>	..	<i>Report on Veterinary Research, Department of Agriculture, Union of South Africa, Pretoria.</i>
<i>Res. & Ind.</i>	..	<i>Research & Industry, New Delhi.</i>
<i>Res. Ser., Indian Coun. agric. Res.</i>	..	<i>Research Series, Indian Council of Agricultural Research, New Delhi.</i>
<i>Rev. Bot. appl.</i>	..	<i>Revue de botanique appliquee et d'agriculture coloniale (tropicale), Paris.</i>
<i>Rice J.</i>	..	<i>Rice Journal (and Southern Farmer), New Orleans.</i>
<i>Rice News Teller</i>	..	<i>Rice News Teller, New Delhi.</i>
<i>Riz et Rizic.</i>	..	<i>Riz et Riziculture, Paris.</i>
<i>Science</i>	..	<i>Science, New York.</i>
<i>Sci. & Cult.</i>	..	<i>Science and Culture, Calcutta.</i>
<i>Sci. Monogr., Indian Coun. agric. Res.</i>	..	<i>Scientific Monograph, Indian Council of Agricultural Research, New Delhi.</i>
<i>Sci. News Lett., Wash.</i>	..	<i>Science News Letter, Washington.</i>
<i>Sci. Progr.</i>	..	<i>Science Progress, Washington.</i>

<i>Sci. Ser., Dep. Agric., Malaya</i>	..	Scientific Series. Department of Agriculture, Federation of Malaya, Johore Bahru.
<i>S. Indian Hort.</i>	..	South Indian Horticulture, Coimbatore.
<i>Soap Perfum. Cosm.</i>	..	Soap, Perfumery & Cosmetics, London.
<i>Soil & Pl. Fd</i>	..	Soil and Plant Food, Tokyo.
<i>Soil Sci.</i>	..	Soil Science, New Brunswick, N.J.
<i>Span</i>	..	Span, Croydon, Surrey.
<i>Spec. Bull. Dep. Agric. Punjab</i>	..	Special Bulletin of the Department of Agriculture, Punjab.
<i>Statist. Yearb., United Nations</i>	..	Statistical Yearbook, United Nations, New York.
<i>Tanner</i>	..	Tanner, Bombay.
<i>Taxon</i>	..	Taxon, Utrecht.
<i>Tea Quart.</i>	..	Tea Quarterly, Nuwara Eliya, Talawakelle.
<i>Tech. Bull. U.S. Dep. Agric.</i>	..	Technical Bulletin, United States Department of Agriculture, Washington.
<i>Tech. Rep. sci. adv. Bd, Indian Coun. med. Res.</i>	..	Technical Report of the Scientific Advisory Board, Indian Council of Medical Research, New Delhi.
<i>Tobacco, N.Y.</i>	..	Tobacco, New York.
<i>Tob. Bull.</i>	..	Tobacco Bulletin, Madras.
<i>Tocklai exp. Sta. Memor.</i>	..	Tocklai Experimental Station Memorandum, Assam.
<i>Trans. Bose Res. Inst.</i>	..	Transactions of the Bose Research Institute, Calcutta.
<i>Trans. Brit. mycol. Soc.</i>	..	Transactions of the British Mycological Society, London.
<i>Trop. Agriculture, Trin.</i>	..	Tropical Agriculture, Trinidad.
<i>Trop. Agriculturist</i>	..	Tropical Agriculturist and Magazine of the Ceylon Agricultural Society, Peradeniya.
<i>W. Ind. Bull.</i>	..	West Indian Bulletin, Barbados.
<i>World Crops</i>	..	World Crops, London.
<i>World Petrol.</i>	..	World Petroleum, New York.
<i>Yearb. Soap Perfum. Cosm.</i>	..	Soap, Perfumery & Cosmetics Year Book and Buyer's Guide, London.
<i>Züchter</i>	..	Züchter, Zeitschrift für theoretische und angewandte Genetik, Berlin.

RAW MATERIALS
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N

NANDINA Thunb. (*Berberidaceae*)

A monotypic genus, represented by *N. domestica*, native of China and Japan introduced into India and grown in gardens.

N. domestica Thunb.

Chittenden, III, 1345; Steward, 124, Fig. 115.

An evergreen handsome shrub, 0.9–2.4 m. high, with bi- or tri-pinnate leaves and narrow lanceolate leaflets; flowers white, numerous, in large terminal panicles; fruit a berry, red or purplish red, rarely white, with two seeds.

N. domestica with its numerous cane-like stems, has much the aspect of a bamboo and is grown in gardens for its graceful foliage. It may be planted in pots and used for indoor decoration. The plant is propagated by seeds, cuttings or by divisions of suckers. It thrives well at medium altitudes under partial shade and withstands considerable frost when the wood is ripe (Gopalaswamiengar, 298; Bailey, 1947, II, 2105).

The wood of *N. domestica* is used for chopsticks and canes in China. The fruits are used as a folk remedy in Japan. Various parts of the plant yield, on distillation, hydrocyanic acid and acetone; tender leaves contain ascorbic acid (c. 10 mg./100 g.) in the reduced form. Fruits, seeds and root and stem bark contain alkaloids (total alkaloids in seeds, c. 0.7%). The following alkaloids, belonging to the iso-quinoline group, have been isolated: nandinine ($C_{19}H_{19}O_4N$, m.p. 145–46°) and its isomers, domesticine (m.p. 115–17°) and isodomesticine; nantenine (domesticine methyl ether, $C_{20}H_{21}O_4N$, m.p. 138.5°); nandazurine ($C_2H_11O_6N_2$), protopine, berberine and jatrorrhizine. Crude nandinine (which is a convulsive poison somewhat similar in its action to dicentrine. Nantenine acts on the central nervous system producing increased reflex action: on the cardiac muscles it causes bradycardia and weakening of heart leading to fall in blood pressure (Neal, 306; U.S.D., 1947, 1529; *Chem. Abstr.*, 1944, 38, 3690; 1951, 45, 8087, 8208; 1950, 44, 4202; Manske & Holmes, IV, 86, 109, 128; Henry, 315–16, 329, 343).

The seeds yield (up to 9.4%) a fatty oil having the following constants: d_4^{15} , 0.9355; n_d^{20} , 1.4742; acid val., 21.6; sap. val., 181.8; iod. val., 132.1; and

unsapon. matter, 4.56%. The fatty acids present are: saturated (palmitic and stearic), 32.3%; and unsaturated (linoleic and oleic with traces of linolenic), 67.7%. Seeds contain also fumaric acid (*Chem. Abstr.*, 1954, 48, 9717; 1952, 46, 1782; 1959, 53, 8542).

NANNORRHOPS H. Wendl. (*Palmae*)

D.E.P., V, 317; C.P., 776; Fl. Br. Ind., VI, 429; Blatter, 81, Pl. 21 & 22.

A small genus of stoloniferous bushy palms distributed from W. Pakistan to the Persian Gulf. One species is occasionally cultivated in gardens in N. India.

N. ritchieana H. Wendl. (MAZARI PALM) is a low shrubby palm with large fan-shaped leaves arising in tufts from a branched underground rhizome, sometimes from erect stems up to 7 m. high; spadix much-branched; fruit globose, 1-seeded; seed hard, spherical or ovoid, 9–16 mm. diam., dark brown, minutely wrinkled. The palm grows gregariously in its natural habitat covering considerable stretches of dry stony ground. It may be propagated by seeds or offsets (Beccari & Martelli, *Ann. R. bot. Gdn Calcutta*, 1931, 13, 35; Troup, III, 973–74).

The leaves of the palm are used for mats, baskets, fans, etc. They yield a coarse, harsh fibre of dull colour, fairly strong but brittle. Chemical analysis of fibre gave the following values: moisture, 10.3; ash, 2.0; α -hydrolysis loss, 14.2; β -hydrolysis loss, 20.7; acid purification loss, 3.8; and cellulose, 65.2%. The fibre is locally used for rope and cordage (*Bull. imp. Inst., Lond.*, 1906, 4, 251).

Tender leaf buds, inflorescence and fruits are eaten. Young leaves are reported to be used as purgative in veterinary medicine. Seeds are strung into rosaries (Beccari & Martelli, loc. cit.; Kirt. & Basu, IV, 2567).

Napellus, Indian — see *Aconitum*

Napier Grass — see *Pennisetum*

NAPOLEONA Beauv. (*Lecythidaceae*)

Chittenden, III, 1346.

A genus of glabrous trees or shrubs native of tropical Africa. One species, *N. imperialis* Beauv., a handsome shrub with *Passiflora*-like flowers is reported to be grown as an ornamental in Calcutta gardens.

NAPOLEONA

The tree can be propagated by cuttings, planted during rains (Firminger, 524).

The fruits which are globose have an edible pulp. The seeds are said to be used as a substitute or an adulterant of Kola (*Cola acuminata*). They contain saponin, but no caffeine. The wood is tough, hard and close-grained; the knotted stems are said to be used for hoe and axe handles (Burkill, II, 1533; Hoppe, 596; Dalziel, 70).

Naranjada Bark — see *Cinchona*

NARAVELIA DC. (*Ranunculaceae*)

D.E.P., V, 317; Fl. Br. Ind., I, 6.

A small genus of woody climbers distributed in the Indo-Malaysian region. One species is found in India.

N. zeylanica DC. (BENG.—*Chagul-bati, murcha*; TAM.—*Vathomkolli, neendavalli*; MAL.—*Kuruppa-kodi*; NEPAL.—*Rashgagri*; LEPCHA—*Tumbum-chilop*; ASSAM—*Gorap-choi*; GARO—*Behalisham*; KHASI—*Jyrmai-lasam*) is a scandent or climbing shrub found in the tropical forests of eastern Himalayas, Assam, Bengal, Bihar and in the greater part of Deccan Peninsula. Roots tuberous; leaves with two opposite, ovate-cordate leaflets and a terminal 3-branched tendril; flowers in panicles, small with a pleasant scent; achenes red, with long feathery styles. The plant may be propagated by seeds or cuttings (Firminger, 633; Chittenden, III, 1346).

The stems can be twisted into rough but strong ropes; they are also reported to be used as tooth-sticks to cure toothache. Roots when crushed emit a smell, which is said to relieve headache (Fl. Assam, I, 6; Rama Rao, 2).

NARCISSUS Linn. (*Amaryllidaceae*)

A genus of bulbous plants, native of Central Europe and the Mediterranean region, extending eastward to China and Japan. Commonly known as Daffodils and Narcissi, they are cultivated for their graceful flowers. Numerous species and varieties of the genus are reported to be grown in Indian gardens; some are found wild as escapes.

Narcissi can be grown in open gardens or in pots, boxes or bowls. They require a well-drained light soil composed of vegetable mould, farmyard manure, loam and sand. They do not thrive so well in the plains as on hills and are usually propagated by bulbs, though they can also be grown from seeds. Bulbs are planted (15–22 cm. apart each way) in

September-October extending to December in the plains and in February on the hills. When grown in pots, 1–3 bulbs are planted 7–8 cm. deep. The plants are in full bloom in about three months of planting and once planted, they may be left undisturbed for 3 years or more [Chittenden, III, 1350–51; Bailey, 1947, II, 2107; Firminger, 336; Khan, *Punjab Fr. J.*, 1960, 23(80), 22].

N. jonquilla Linn. **JONQUIL**

Bailey, 1947, II, 2112, Fig. 2448.

A slender perennial bulbous herb, up to 45 cm. in height, found in S. Europe and Algeria, and cultivated in Indian gardens as an ornamental plant. Leaves glossy dark green, narrow, rush-like; flowers 2–6, yellow with short cup-shaped, crenate corona, fragrant.

N. jonquilla is the source of an essential oil used in perfumery, and is cultivated in the Grasse region of southern France. The perfume is obtained by extracting the flowers with petroleum ether or by maceration with hot fat at 50–70°. Petroleum ether extraction yields 0.25–0.51% (usually 0.35–0.45%) of a waxy concrete which gives 40–45% of a viscous, dark brown absolute containing 3–7% of a steam-volatile oil. The pomade obtained by maceration is dark brown-yellow and yields 1.55–1.80% of a concentrate; a light coloured pomade is obtained by enfleurage. The volatile oil contains methyl and benzyl benzoates, esters of cinnamic acid (including methyl cinnamate), linalool, methyl anthranilate and indole; jasmone has been identified in the absolute. Jonquil absolute is valued for use in high grade perfumes of the French type. It imparts heavy tonalities to floral as well as oriental scents (Guenther, V, 351–52; Naves & Mazuyer, 201–02).

N. tazetta Linn. **POLYANTHUS NARCISSUS**

D.E.P., V, 317; Bailey, 1949, 259; 1947, II, 2111, Fig. 2447.

PUNJAB—*Nargis, irisa*.

A variable herb found from Canary Islands to Japan and grown in Indian gardens as an ornamental. Leaves long, flat; flowers few to several borne on stalks 30–50 cm. high, white, with cup-shaped, lemon-yellow corona, fragrant.

N. tazetta is cultivated in the Grasse region of southern France for its fragrant flowers. On extraction with petroleum ether, the flowers yield 0.21–0.45% (usually 0.25–0.28%) of a concrete which gives 27–32% of a viscous, greenish brown absolute containing 2.2–3.5% of a steam-volatile oil. The volatile oil has

such a strong odour as to cause headache ; it contains eugenol, benzyl alcohol, cinnamyl alcohol, benzaldehyde, and free and esterified benzoic acid. The absolute is a valuable adjunct in high grade perfumes of the French type. It imparts exquisite, strong and heavy tonalities difficult to identify. *Narcissus* perfume blends particularly well with jasmine (Guenther, V, 348-50 ; Poucher, II, 177).

Three alkaloids, viz. tazettine ($C_{14}H_{21}O_5N$, m.p. $212-13^\circ$), lycorine ($C_{16}H_{17}O_5N$, m.p. $276-80^\circ$) and suisenine ($C_{17}H_{19}O_5N$, m.p. 229°), all having a phenanthridine nucleus, have been isolated from the bulbs. Tazettine is the principal alkaloid and is identical with sekisanine (from *Lycoris radiata*) which is pharmacologically inactive (Manske & Holmes, II, 333 ; Henry, 406-12).

The bulbs of the plant are said to be imported into Bombay, dried, sliced and sold in the bazaar as a substitute for bitter hermodactyls. They possess emetic, purgative, diuretic and absorbent properties. They are reported to be poisonous (*Chem. Abstr.*, 1943, 37, 1773).

Nard, Indian — see *Nardostachys*

NARDOSTACHYS DC. (*Valerianaceae*)

A small genus of two species of herbs native of India.

N. jatamansi DC. SPIKENARD, INDIAN NARD D.E.P., V, 338 ; VI (1), 138 ; C.P., 792 ; Fl. Br. Ind., III, 211.

SANS.—*Jatamansi* ; HINDI—*Jatamansi, bal-chir* ; BENG.—*Jatamansi* ; MAR.—*Jatamavshi* ; GUJ.—*Jatamasi, kalichhad* ; TEL., KAN. & MAL.—*Jatamamishi* ; TAMIL.—*Jatamashi*.

KASHMIR—*Bhutijatt, kukilipot* ; GARHWAL—*Masi* ; NEPAL—*Ilaswa, naswa, jatamangsi* ; BHUTAN—*Pampe, jatamansi*.

An erect perennial herb, 10-60 cm. high, with long, stout, woody rootstock found in the alpine Himalayas from Punjab to Sikkim and Bhutan, at altitudes of 3,000-5,000 m. Radical leaves elongate spathulate, caudine leaves sessile, few, oblong or sub-ovate ; flowers rosy, pale pink or blue, in dense cymes.

The plant is propagated by cuttings of underground parts and sometimes by seeds. It is valued for its rhizomes (commonly called roots) used in India as a drug and also in perfumery. The drug (*Jatamansi* or *Nardus Root*) consists of short, thick, dark grey rhizomes crowned with reddish brown tufted fibrous



FIG. 1—NARDOSTACHYS JATAMANSI—WITH ROOTSTOCKS

remains of the petioles of radical leaves. The rhizomes are collected from wild plants and sent to markets in the plains ; it is reported that c. 18,650 kg. of the drug are brought into Punjab markets annually. The roots of valerian and *Cymbopogon schoenanthus* are often mistaken for *jatamansi*. Recently roots and rhizomes of *Selimum vaginatum* C. B. Clarke have been found as adulterants of *jatamansi* (Luthra & Suri, *Spec. Bull. Dep. Agric. Punjab*, 1936, 12 ; I.P.C., 157 ; Datta & Mukerji, *Bull. Pharmacogn. Lab.*, No. 1, 1950, 72 ; Mehra & Jolly, *Indian J. Pharm.*, 1962, 24, 47).

Jatamansi has an agreeable odour with a bitter aromatic taste and is used as a substitute for valerian (*Valeriana officinalis* Linn.). It yields up to 1.9% of a pale yellow essential oil (Spikenard Oil) with a pleasant odour, suggestive of patchouli and valerian. The oil resinifies on exposure to air. A sample of oil obtained from Indian rhizomes had the following characteristics: sp. gr.²⁴, 0.9608 ; n^{24} , 1.4990 ; $[\alpha]^{24}, +31^\circ$; sap. val., 23.2 ; and sap. val. after acetylation, 50.9. The Indian oil is *d*-rotatory while oils from Japan are reported to be *l*-rotatory. Spikenard oil con-

NARDOSTACHYS

tains an alcohol ($C_{15}H_{22}O$) and its iso-valeric ester ; a saturated bicyclic sesquiterpene ketone, jatamansone ($C_{15}H_{20}O$, b.p. $108^{\circ}/1$ mm.), has been isolated from the rhizomes. An acid, named jatamanshic acid ($C_{15}H_{22}O_2$, m.p. 123°), has been separated from some samples of the drug (Finnemore, 825 ; Poucher, I, 375 : Chaudhry *et al.*, *J. sci. industr. Res.*, 1958, **17B**, 159, 473 ; 1951, **10B**, 48 : Govindachari *et al.*, *Chem. Ber.*, 1958, **91**, 908).

Spikenard oil possesses antiarrhythmic activity with possible therapeutic usefulness in cases of auricular flutter ; it is less effective than quinidine, but has the advantage of being less toxic. Jatamansone is more potent than the oil and is also more active than quinidine in ventricular tachycardia resulting from acute myocardial infarction ; in experimentally induced arrhythmias it is as effective as quinidine except in the acetylcholine induced auricular fibrillation, in which it is considerably weaker. Jatamansone possesses anticonvulsant action as well. The oil exerts a hypotensive effect and in moderate doses it has a distinct depressant action on the central nervous system : lethal doses cause deep narcosis and ultimately death within a few hours. The root extracts show sedative properties (Arora & Madan, *Indian J. med. Res.*, 1956, **44**, 259 ; Arora *et al.*, *ibid.*, 1958, **46**, 782 ; Chopra *et al.*, *ibid.*, 1954, **42**, 386 ; *Biol. Abstr.*, 1958, **32**, 2558 ; Hamied *et al.*, *J. sci. industr. Res.*, 1962, **21C**, 100).

The rhizome is considered tonic, stimulant, anti-spasmodic, diuretic, deobstruent, emmenagogue, stomachic and laxative. An infusion of the rhizome is reported to be useful in epilepsy, hysteria, palpitation of heart and chorea. A tincture of it is given in intestinal colic and flatulence. The rhizome is used as an aromatic adjunct in the preparation of medicinal oils : it is reported to promote the growth of hair and also impart blackness (Kirt. & Basu, II, 1308 ; I.P.C., 158 : Gujral, *J. Indian med. Ass.*, 1955, **25**, 49 ; Chopra, 1958, 679).

NAREGAMIA Wight & Arn. (Meliaceae)

A monotypic genus, represented by *N. alata*, native of India.

N. alata Wight & Arn. GOANESE IPECACUANHA
D.E.P., V, 342 ; Fl. Br. Ind., I, 542 ; Kirt. & Basu,
Pl. 217.

MAR.—*Tinpani*, *pittvel*, *pittappra* ; TEL.—*Pagappu* ; KAN.—*Nelanaaringu* ; MAL.—*Nelanaragam*.

A small branched undershrub found in the western

ghats from Konkan southwards, ascending up to 900 m. Leaves trifoliolate : leaflets small, cuneate-ovoblate ; flowers white, solitary or 2 together, axillary ; capsules ovoid-globose.

The creeping roots of the plant are said to possess properties akin to Ipecacuanha (*Cephaelis ipecacuanha*). They have a pungent aromatic odour and are considered emetic, cholagogue and expectorant ; they are also useful in chronic bronchitis. The root bark contains an alkaloid naregamine, fatty oil, wax, sugar and resins (Chopra, 1958, 230, 679 ; Kirt. & Basu, I, 536 ; Wehmer, II, 661).

The plant is reported to be used in S. India in rheumatism and itch. In Konkan, the leaves and stem are given in a decoction with bitters and aromatics as a remedy for biliousness. The plant is used as an ingredient of a compound powder preparation which is given in malarial and chronic fevers, anaemia and enlarged spleen (Kirt. & Basu, I, 536 ; Chopra, 1958, 679 ; Koman, 1918, 18).

NARENGA Bor (Gramineae)

A very small genus of tall perennial grasses distributed in tropical parts of South-East Asia. Two species occur in India.

N. porphyrocoma (Hance) Bor syn. *Saccharum narenga* Wall.

Fl. Br. Ind., VII, 120 ; Bor, *Indian For. Rec.*, N.S., Bot., 1941, **2**(1), 153, Pl. 38 & 39.

MADHYA PRADESH—*Ronsa* ; UTTAR PRADESH—*Ganeria*, *kanwal*, *tanwear* ; ASSAM—*Bata*, *barota*.

A slender perennial grass, with culms 2.0-2.5 m. tall, found in the sub-Himalayan tract from Garhwal to Assam at 900-1,200 m. and also in Bihar and Orissa. Leaf-blades glabrous above, scabrid below, 30-60 cm. long, 6 mm. broad ; inflorescence a narrow dense panicle, 30-45 cm. long.

This is the commonest and most widely distributed savannah grass of sal forests and is a valuable indicator of soil moisture conditions suitable for sal (*Shorea robusta* Gaertn. f.). It is a good soil binder. The young and immature leaves are browsed by cattle and when required for grazing, the grass land is fired so that the young leaves become available for fodder in hot season [Hole, *Indian For. Mem., For. Bot. Ser.*, 1911, **1**(1), 80].

The culms are said to be more tough than of Munj (*Saccharum bengalense* Retz.) and are used for thatching, for rough mats and screens (Haines, V, 1013 ; Burkill, II, 1924).

***NASTURTIUM R. Br. (*Cruciferae*)**

A small genus of herbs distributed in the northern hemisphere. One species occurs in India.

N. officinale R. Br. syn. N. fontanum Aschers.**WATER CRESS**

D.E.P., V, 342; Fl. Br. Ind., I, 133.

PUNJAB—*Piriya halim*; DECCAN *Lut-putiah*.

A perennial much-branched, aquatic herb with creeping or floating stem, native of Europe, N. Africa and W. Asia; it is naturalized in many countries, including India, and is commonly found in ditches, pools and margins of shallow streams up to an altitude of 2,100 m. Leaves pinnate: leaflets 7–11, sessile, ovate-oblong or sinuately lobed, obtuse; flowers white, in short racemes; fruit a siliqua, shortly cylindric; seeds minute, ovoid, muriculate.

N. officinale is cultivated as a salad plant in England and in parts of America. It requires well-prepared beds supplied with slow flowing, clean, uncontaminated water; it does not thrive in stagnant water. It is propagated either by seeds or by cuttings. The former method is employed for securing plants required for large plantings. Seeds are sown broadcast in well-prepared, moist beds. After the first leaves emerge, enough water is let into the beds to cover the plants. When well established, seedlings are pulled out in tufts and transplanted in canals and ponds with flowing water, or set 30 cm. apart in beds and sufficient water turned in to cover the plants. For propagation by cuttings, the planting material is set 10 cm. apart in rows running parallel to the course of water and the supply of water maintained from the beginning till the plants are well established. Tender shoots, c. 15 cm. long with an abundance of fresh leaves, are harvested and pieces tied into bundles and kept in water until required for use (Oldham, 254–55, 257; Beattie, *Leafl. U.S. Dep. Agric.*, No. 134, 1938; Thompson & Kelly, 274; Collan, 38).

Water cress is consumed raw as salad; it is used also as garnish for various dishes. It is sometimes boiled and cooked as vegetable. Chopped leaves are incorporated in fruit and vegetable juice cocktails, soups and biscuits (Muenscher & Rice, 187, 189; Bhargava, *J. Bombay nat. Hist. Soc.*, 1959, 56, 26).

Water cress possesses antiscorbutic and stimulant properties and is eaten to improve appetite. It is a

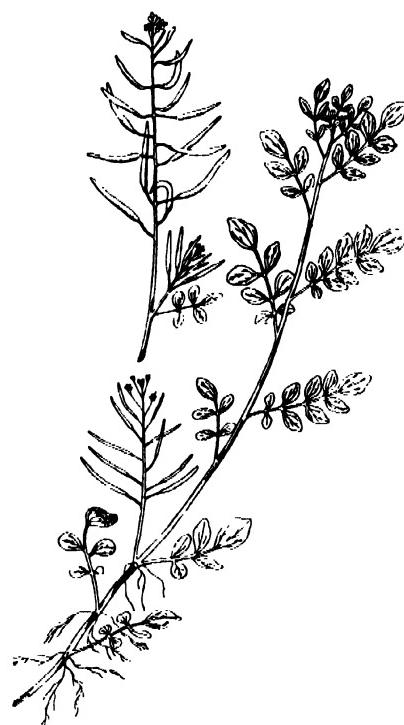


FIG. 2—NASTURTIUM OFFICINALE—FLOWERING AND FRUITING BRANCHES

good source of vitamins and minerals. Analysis of Indian water cress gave the following values: moisture, 89.2; protein, 2.9; fat (ether extr.), 0.2; carbohydrates, 5.5; and mineral matter, 2.2%: calcium, 290; phosphorus, 140; and iron, 4.6 mg./100 g. Water cress is rich in sulphur, iodine and manganese; the calcium present in it is well assimilated; zinc, arsenic and copper are reported to be present in traces. The dehydrated vegetable possesses excellent supplementary value to the proteins of milled wheat flour and milled white corn meal; at 5% level in the diet, it is superior to spinach, cauliflower, lettuce and green beans. The amino acid composition of the proteins of water cress is as follows: leucine, 3.0; phenylalanine, 1.0; valine, 1.2; lysine, 1.5; tyrosine, 0.6; alanine, 1.0; threonine, 1.5; glutamic acid, 2.7; serine, 0.6; aspartic acid, 4.0; cystine, 1.0; methionine sulphoxide, 0.1; and proline, 0.4 mg./g. (Kirt. & Basu, I, 146; Muenscher & Rice, 189; *Health Bull.*, No. 23, 1951, 34; McCance & Widdowson, 91; Winton & Winton, II, 247; Wehmer, I, 414; *Chem. Abstr.*,

* Some authors do not regard this genus to be distinct from *Rorippa* Scop.; according to them the name of Water Cress is *Rorippa nasturtium-aquaticum* (Linn.) Hayek (Mansfeld, 106; Chittenden, IV, 1809, 2265).

NASTURTIUM

1937, 31, 2254; 1948, 42, 2332; Kuppuswamy et al., 110; Majumder et al., *Food Res.*, 1956, 21, 477).

Water cress is a rich source of vitamins A and E ; it is also a good source of ascorbic acid. It contains: vitamin A, 4720 I.U. ; thiamine, 0.08 ; riboflavin, 0.16 ; niacin, 0.8 ; and ascorbic acid, 77 mg./100 g. ; biotin, 0.5 γ/100 g. It has been used therapeutically for correcting vitamin deficiency (Lachat, 35 ; Watt & Merrill, *Agric. Handb. U.S. Dep. Agric.*, No. 8, 1952, 26 ; *Chem. Abstr.*, 1953, 47, 5575 ; 1930, 24, 5803).

The finely comminuted herb on distillation gives 0.06% of an essential oil consisting mainly of phenylethyl isothiocyanate. The latter occurs in the herb as the glucoside, gluconasturtiin ($C_{15}H_{20}O_9S_2NK$), which is hydrolyzed by myrosinase to glucose, phenylethyl isothiocyanate and potassium hydrogen sulphate [Gildemeister & Hoffmann, V, 179 ; Krishna & Badhwar, *J. sci. industr. Res.*, 1947, 6(3). suppl., 33 ; McIlroy, 25].

The seeds of water cress contain gluconasturtiin and a non-drying fatty oil (24%) with the following characteristics: sp. gr. 1.5° , 0.9205 ; n^{20} , 1.4704 ; acid val., 2.2 ; sap. val., 170.9 ; iod. val., 98.6 ; unsapon. matter, 1.1% ; and solid. p., -5 to -6° (Thorpe, VI, 89 ; Eckey, 446).

Water cress is reported to be useful in strangury and goiter ; the juice is used as a cure for polypus of the nose. It possesses antibacterial properties and is used for dry throat and cold in the head, asthma and tuberculosis. A decoction of the plant is given as a blood purifier, vermifuge and diuretic (Steinmetz, II, 314 ; Bushnell et al., *Pacif. Sci.*, 1950, 4, 171).

Nasturtium spp.—*see Rorippa*

Naticids—*see Molluscs*

NATSIATUM Buch.-Ham. (*Icacinaceae*)

Fl. Br. Ind., I, 595.

A monotypic genus of climbing shrubs distributed in the Himalayas from Nepal to Assam and in Burma.

N. herpeticum Buch.-Ham. (MIRI—*Target-riube* ; LEPCHA—*Sungoo-rik*) is found up to an altitude of 900 m. in the Himalayas from Nepal to Sikkim, N. Bengal, Bihar, Assam and Khasi hills and further south in Orissa and N. Circars. Roots tuberous ; stem almost white ; leaves membranous, cordate-ovate ; flowers dioecious in racemes ; fruit an ovate drupe.

The leaves and tender shoots are eaten cooked as a pot-herb, especially with fish (Fl. Assam, I, 253).

NAUCLEA Linn. (*Rubiaceae*)

A genus of trees or shrubs distributed in Africa, Indo-Malaysian region, China, Japan, Australia and Polynesia. Three species are found in India.

N. orientalis Linn. syn. *Sarcocephalus cordatus* Miq. D.E.P., VI (2), 476 ; Fl. Br. Ind., III, 22 ; Bentham, 276, Fig.

A medium-sized ornamental tree with a bushy crown and a bole, up to 9 m. in length and 2 m. in girth, found in Cachar hills in Assam ; it is cultivated in gardens. Bark smooth, greyish ; leaves large, broadly ovate or cordate ; flowers in globose heads, small, yellow or orange, fragrant ; fruit composite, globose, fleshy, 1.5–2.5 cm. in diam. ; seeds small, albuminous.

The tree yields a pale to orange-yellow wood, the colour fading off with age. The wood is smooth with a waxy feel, straight-grained, medium coarse- and even-textured, soft and light (sp. gr. c. 0.55 ; wt., 609 kg./cu. m.). It does not split during seasoning, but is liable to stain. Prompt conversion after felling and open stacking of boards in well-ventilated sheds is recommended. The wood is not durable, but a coating of antiseptic or crude oil prolongs the life. It is easy to saw and work to a good finish. The timber is used for door frames and general house construction, furniture, packing cases and cabinet work. It is suitable for turnery and carving. It is regarded as suitable for paper pulp in Indo-China (Pearson & Brown, II, 617–19 ; Lewis, 222 ; Rodger, 26 ; Desch, 1954, II, 504).

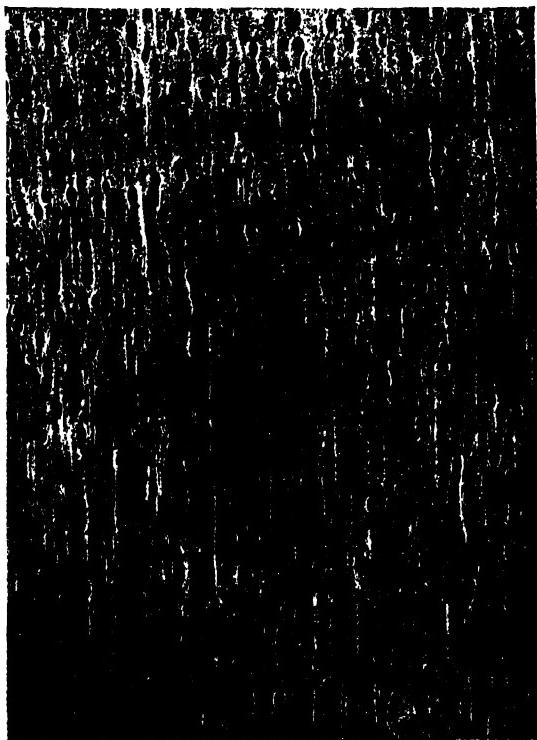
The bark, leaves and wood contain bitter principles. The bark contains also a canary-yellow colouring matter, but no alkaloid ; it is reported to be used as tonic and antipyretic ; a decoction is used as vulnerary. Leaves are applied to boils. The bark is used as fish poison. The fruits are edible ; they are reported to be eaten in Ceylon. Young fruits are attacked by the caterpillars of *Scaeosopha chionoscia* Meyrick (Kirt. & Basu, II, 1250 ; Quisumbing, 920 ; Wehmer, II, 1167 ; Webb, *Bull. Coun. sci. industr. Res. Aust.*, No. 232, 1948, 141 ; Webb, *Bull. sci. industr. Res. Org. Aust.*, No. 268, 1952, 73 ; Lewis, 222 ; Mathur et al., *Indian For. Bull.*, N.S., No. 223, 1958, 63).

N. sessilifolia Roxb. syn. *Adina sessilifolia* Hook. f. D.E.P., I, 115 ; Fl. Br. Ind., III, 24.

A medium-sized tree with a fairly straight bole, up to 9 m. in length and 2 m. in girth, found in Cachar in Assam. Bark blackish, transversely fissured; leaves elliptic-oblong or ovate; flowers in terminal heads, silky; capsules small, cuneate.

The tree occurs chiefly in mixed deciduous forests and natural reproduction is abundant on flat alluvial ground along rivers and streams. It yields a light yellowish brown to pale orange-brown wood with darker streaks. The wood is somewhat lustrous with smooth greasy feel, straight to interlocked-grained, medium and even-textured, fairly strong, hard and heavy (sp. gr., c. 0.81; wt., 833 kg./cu. m.). It seasons well with care after green conversion. Museum specimens of the wood have been preserved in sound condition for 40 years. The timber is easy to saw but is hardly so good for turnery as that of *Adina cordifolia* (q.v.). It is used in house construction and as planks, scantlings and posts (Troup, II, 624; Pearson & Brown, II, 627-29).

The bark is considered astringent, tonic and styptic. It is used for bowel complaints and fever. The wood is considered depurant and tonic (Kirt. & Basu, II, 1255).



F.R.I., Dehra Dun. Photo : S. S. Ghosh

FIG. 3—NAUCLEA SESSILIFOLIA—TRANSVERSE SECTION OF WOOD ($\times 10$)

N. missionis Wight & Arn. syn. *Sarcoccephalus missionis* Haviland (TAM. & MAL.—*Attu vanji*; KAN.—*Anavu*; BOMBAY—*Phuga*) is a small to medium-sized tree with smooth, dark coloured bark, elliptic-lanceolate leaves and yellowish fragrant flowers in heads found from Konkan to Travancore, especially along rivers and water courses. The bark is used for skin diseases, rheumatism and constipation. The tree yields a yellow, moderately hard, light wood (wt., 545-93 kg./cu. m.) which is rough and cross-grained (Kirt. & Basu, II, 1249; Bourdillon, 186-87).

Nauclea spp. — see *Neonauclea*

Nectarine — see *Prunus*

Neem — see *Azadirachta*

Negro Coffee — see *Cassia*

*NELSONIA R. Br. (*Acanthaceae*)

A monotypic genus, represented by *N. canescens*, distributed in Africa, Asia and Australia, and introduced in tropical America.

N. canescens (Lam.) Spreng. syn. *N. campestris* R. Br.

Fl. Br. Ind., IV, 394; Bremekamp, *Reinwardtia*, 1954-56, 3, 248.

A decumbent villous herb with tuberous roots found throughout India except in the western desert areas and ascending to 1,200 m. in the Himalayas. Leaves elliptic-oblong: lower leaves petiolate, very large, upper leaves smaller, sessile or sub-sessile; flowers blue, purplish or white, in ovoid or cylindric spikes; fruit an ovoid-conic capsule containing 8-12 seeds.

The plant is slightly acid to taste and has been used as a substitute for salt. It is used in West Africa as fodder for goats and sheep. In Ghana (Gold Coast), the juice of the plant is squeezed into the eyes to cure fever (Dalziel, 452).

NELUMBO Adans. (*Nymphaeaceae*)

A very small genus of aquatic herbs distributed in Asia, Australia and America. One species occurs in India.

N. nucifera Gaertn. syn. *Nelumbium nelumbo* Druce; *N. speciosum* Willd. SACRED LOTUS, INDIAN LOTUS, CHINESE WATER LILY

D. E. P., V, 343; III, 318; Fl. Br. Ind., I, 116.

* Bremekamp (*Reinwardtia*, 1954-56, 3, 157) places this genus in the family *Scrophulariaceae*.

NELUMBO

SANS.—*Ambuja, padma, pankaja, kamala*; HINDI—*Kanwal, kamal*; BENG.—*Padma*; MAR.—*Kamal*; GUJ.—*Suriyakamal*; TEL.—*Kalung, erratamara*; TAN.—*Amibal, thamarai*; KAN.—*Kamala, tavare-gadde*; MAI.—*Thamara, senthamara*; ORIYA—*Padam*.

KASHMIR—*Pamposh*; PUNJAB—*Kanwal, pamposh*; MUNDARI—*Salukid ba, upal ba, kombol ba*; ASSAM—*Podum*; KHASI—*Soh-lapudong*.

A handsome aquatic herb with stout, creeping rhizome found throughout India, ascending up to 1,800 m. Leaves peltate, 60–90 cm. or more in diam., orbicular, glaucous: petioles very long, smooth or with small prickles; flowers solitary, large, white or rosy; fruit-torus large, top-shaped, 5–10 cm. diam., spongy, with many (10–30) uniovulate carpels sunk separately in cavities on the upper side; carpels maturing into ovoid nut-like achenes.

N. nucifera is a native of China, Japan and possibly India. It is commonly found growing in ponds, tanks and *jheels*; it is often cultivated for its elegant sweet-scented flowers. Many cultivated races with flowers ranging in colour from white to deep rose and variegated leaves are known in Japan. Lotus is cultivated in China and Japan, in terraced fields, for its edible rhizomes and seeds. Propagation is usually by

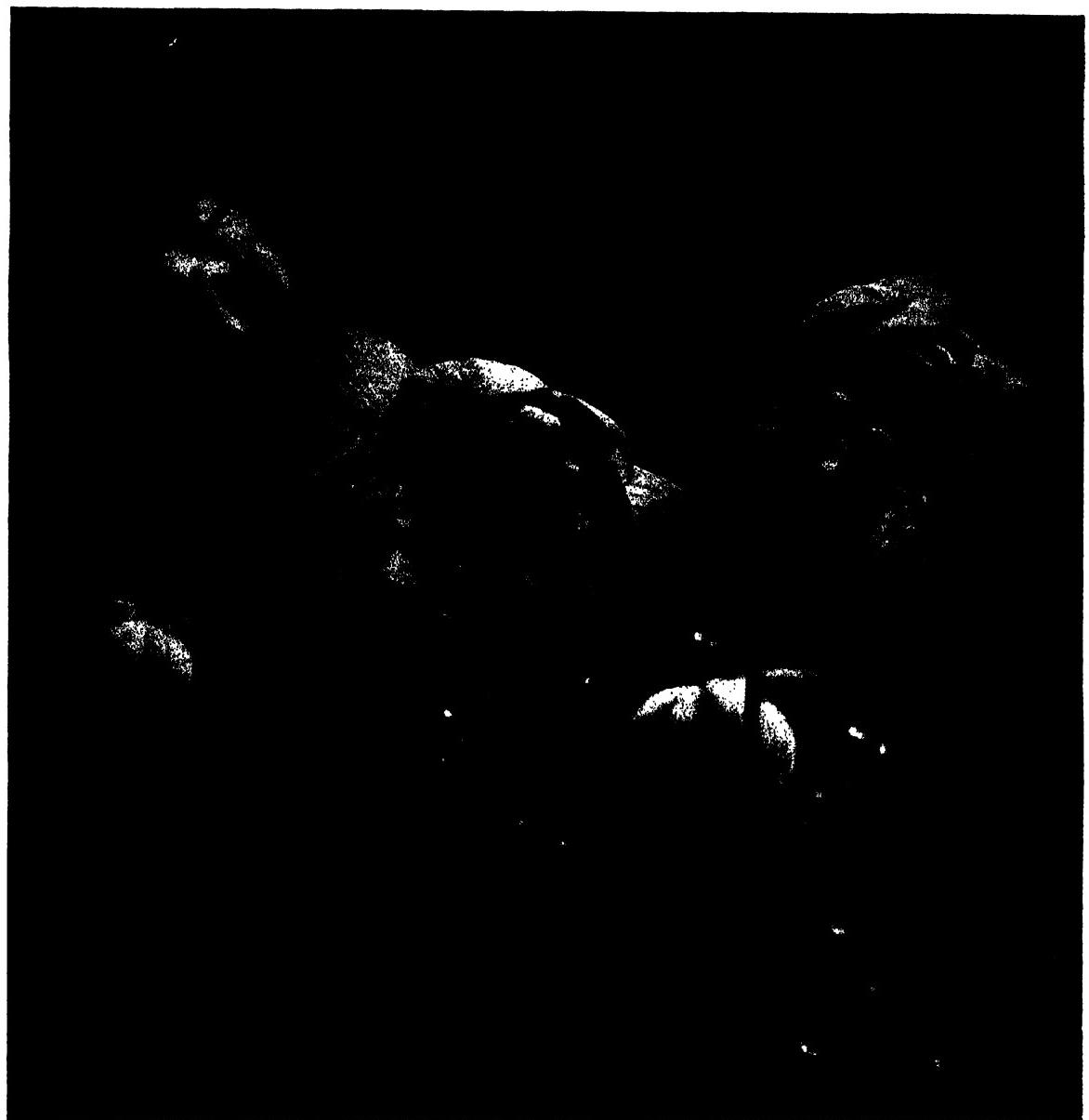
rhizomes; the plant may also be propagated from seeds. It may be grown in tubs, but pond culture is preferred as it permits the radial spread of rhizomes up to 15 m. a year. The viability of lotus seeds exceeds that of any known species of flowering plant. In Punjab, a small area of c. 60 hectare is reported to be under this crop. Rhizomes, cut into small pieces, are planted with eyes above the soil surface in March-April, care being taken that enough water remains in the pond till October. When grown from seeds, c. 10–12 kg. of seeds are required to give enough nursery seedlings for a hectare. The plant bears flowers in profusion during the hot and rainy season, and seeds ripen towards the end of the rains. The rhizomes are ready for digging in October. The crop is reported to yield 3,600–4,600 kg. of rhizomes per hectare [Vavilov, 24; Bailey, 1947, II, 2117; Burkhill, II, 1539; Irvine & Trickett, *Kew Bull.*, 1953, 363; Wood, *J. Arnold Arbor.*, 1959, 40, 105; Malik, *Indian Fmg.*, N.S., 1961–62, 11(8), 23].

Two types of rhizomes, white and red, are generally met with. The farinaceous rhizomes of the plant are collected and sold as vegetable (*Kamal-kakadi, bhen*). They measure 60–120 cm. in length and 6–9 cm. in diam., are white to buff-orange in colour and show in cross section a few large cavities



FIG. 4—NELUMBO NUCIFERA—A LOTUS POND

Photo : Ramesh Bedi



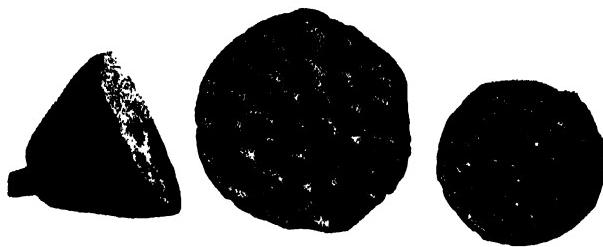
NELUMBO NUCIFERA — IN FLOWER

surrounded by several small ones. They are fleshy and, when freshly cut, exude a mucilaginous juice ; they are somewhat fibrous and do not soften even after prolonged boiling. Fresh rhizomes are eaten after roasting, while dried slices are used in curry or fried as chips ; they are also pickled. They may be preserved in the frozen condition and used as an ingredient in precooked foods. Analysis of fresh rhizomes (from Mysore) gave the following values : water, 83.80 ; crude protein, 2.70 ; fat, 0.11 ; reducing sugars, 1.56 ; sucrose, 0.41 ; starch, 9.25 ; fibre, 0.80 ; ash, 1.10 ; and calcium, 0.06%. The vitamins reported to be present are as follows (in mg./100 g.) : thiamine, 0.22 ; riboflavin, 0.06 ; niacin, 2.1 ; and ascorbic acid, 15. The rhizome contains asparagine (2%) [Malik, loc. cit. ; Irvine & Trickett, loc. cit. ; Bhargava, *J. Bombay nat. Hist. Soc.*, 1959, **56**, 26 ; Moorjani, *Bull. cent. Fd technol. Res. Inst., Mysore*, 1952-53, **2**, 263 ; Shepherd & Neumann, *Chemurg. Dig.*, 1958, **17**(11), 6 ; *Handb. Inst. Nutr. Philipp.*, No. 1, 1957, 18 ; Wehmer, I, 307].

The fruiting torus (*Kamalgatta, chapni*) is often sold for the edible carpels embedded on it. The carpels are round, oval or oblong, hard and dark brown ; they are eaten after removing the outer covering and also the embryo which is intensely bitter. They are sweet and tasty and may be eaten raw, roasted, boiled, candied or ground into flour. *Nelumbo* carpels are considered superior to cereals in nutritive value. Analysis of dried carpels gave the following values : water, 10.0 ; protein, 17.2 ; fat, 2.4 ; total carbohydrates (mostly starch), 66.6 ; fibre, 2.6 ; and ash, 3.8% ; calcium, 136 ; phosphorus, 294 ; and iron, 2.3 mg./100 g. Sucrose (4.1%), reducing sugars (2.4%) and ascorbic acid are present (Moorjani, loc. cit. ; Porterfield, *Econ. Bot.*, 1951, **5**, 10 ; Wu Leung *et al.*, *Agric. Handb. U.S. Dep. Agric.*, No. 34, 1952, 30 ; Irvine & Trickett, loc. cit.).

Alkaloids are reported in the leaves, carpels and rhizomes. The leaves contain three alkaloids, viz. nuciferine (5,6-dimethoxy aporphine, $C_{19}H_{21}O_2N$, m.p. 165.5°), roemerine (m.p. $100-01^\circ$) and nornuciferine ($C_{18}H_{19}O_2N$, m.p. $195-96^\circ$). An alkaloid, nclumbine, which acts as a cardiac poison, has been isolated from petioles, pedicel and seed embryo (Arthur & Cheung, *J. chem. Soc.*, 1959, 2306 ; *Chem. Abstr.*, 1956, **50**, 11441 ; 1961, **55**, 18015 ; Wehmer, I, 307).

The flowers of *N. nucifera* are used for ornament and as offering in temples. Cut flowers stand transportation if picked as buds one or two days before

FIG. 5—*NELUMBO NUCIFERA*—FRUITING TORUS

opening. They were once used as the source of a perfume, Lotus Perfume, which was highly prized ; the present-day lotus perfume is a blend of patchouli, benzoin and storax with phenylethyl and cinnamic alcohols. The honey from bees which visit lotus flowers is reported to possess tonic properties and considered useful for affections of the eye. The leaf stalk yields a yellowish white fibre (Porterfield, *J. N.Y. bot. Gdn.*, 1941, **42**, 280 ; Khan, *Pakist. J. For.*, 1958, **8**, 342 ; Kirt. & Basu, I, 117).

Young leaves, petioles and flowers of the plant are eaten as vegetables. A kind of arrowroot is prepared from the fleshy rhizomes ; it is aromatic and sweet, and is reported to be not only nutritious but also tonic ; it is given to children in cases of diarrhoea, dysentery and dyspepsia. A paste of the rhizome is applied in ringworm and other cutaneous affections. Carpels are demulcent and nutritive and are used to check vomiting. A sherbet prepared from the plant is used as a refrigerant in smallpox and is reported to stop eruption. The milky viscous juice of leaf and flower stalks is used in diarrhoea. Saline extracts of stem, leaves and flowers possess bacteriostatic action against Gram-positive and Gram-negative bacteria (Burkill, II, 1539-40 ; Porterfield, *Econ. Bot.*, 1951, **5**, 10 ; Kirt. & Basu, I, 118-19 ; Nadkarni, I, 844 ; Nickell, *Econ. Bot.*, 1959, **13**, 281).

Nematodes — see Parasitic Worms

NEOHOUEAUA A. Camus (*Gramineae*)

A small genus of bamboos distributed in the Indo-Malayan region. Two species are found in India.

N. dullooa (Gamble) A. Camus syn. *Teinostachyum dullooa* Gamble

C.P., 104 ; Fl. Br. Ind., VII, 411 ; Fl. Assam, V, 21.

ASSAM.—*Dolu*, *dullooa*, *wadru*, *dongla*, *ruathla* ; LEPCHA.—*Puksalu*.

A medium-sized to large, tufted, sometimes scandent, unarmed bamboo found in the eastern

NEOHOUZEAUA

Himalayas, N.E.F.A., Assam, Tripura and Manipur. Culms up to 20 m. long, dark green, whitish below nodes; internodes 40-100 cm. in length, 5-10 cm. in diam.; leaves oblong-lanceolate, often variable.

N. dullooa has attracted attention as a suitable raw material for paper pulp. The culms are thin-walled and soft. Analysis of culms gave the following values (oven dry basis): hot-water extr., 6.61; NaOH (1%) extr., 20.48; pentosans, 18.10; lignin, 23.82; cellulose, 64.64; silica, 0.93; and ash, 1.78%. Pulping tests, using a 2-stage digestion process, gave 45.5% unbleached and 42% of bleached pulp (fibre length, 1-6 mm.; av., 3.63 mm.) suitable for the production of printing and writing paper. The culms can be mixed with other bamboos and digested by the fractional sulphate process to yield easy bleaching pulps (Trotter, 1940, 345; Bhargava, *Indian For. Bull.*, N.S., No. 129, 1945, 24, 20, 6).

Dullooa bamboo is employed as floats for transporting timber along rivers from hilly areas. The culms are used as water pails; they are used also for making umbrellas, baskets and mats and for building purposes (Prasad, *Indian For.*, 1948, 74, 129; Adhikari, *ibid.*, 1932, 58, 472).

N. helferi (Munro) Gamble syn. *Teinostachyum helferi* Gamble (ASSAM—*Wali, tumoh*) is a tufted bamboo forming large impenetrable thickets, found in the hills of Assam. It has internodes up to 1.2 m. long, and is used for basket making (Gamble, 754).

NEOLITSEA Merrill (*Lauraceae*)

A genus of trees or shrubs distributed in the Indo-Malaysian region and China. About 7 species are found in India.

N. cassia (Linn.) Kostermans syn. *N. zeylanica* (Nees) Merrill; *N. involucrata* (Lam.) Alston; *Litsea zeylanica* Nees; Hook. f. (Fl. Br. Ind.) in part

D.E.P., V, 85; Fl. Br. Ind., V, 178; Fyson, II, Fig. 440.

MAR.—*Kanvel, chirchira*; TEL.—*Akupatricum*; TAM.—*Moluga shembaga-palvi*; KAN.—*Bilinisangi, maximara*; MAL.—*Vayana*.

A small or medium-sized tree, up to 18 m. in height and 2.4 m. in girth, found in eastern Himalayas, hills of Assam and Deccan Peninsula up to an altitude of 2,100 m. Bark grey or greyish brown, smooth; leaves ovate or elliptic-lanceolate, crowded at the ends of branches; flowers in small clusters; fruit globose or ovoid, c. 1.25 cm. in diam., dark purple

when ripe. A rust (*Xenostele indica* Thirumalachar) has been recorded on this species (Thirumalachar, *Curr. Sci.*, 1948, 17, 26).

An aromatic oil, Bellary Leaf Oil (yield, 0.4-0.6%) with a sweet sharp odour resembling that of unripe mangoes, is obtained by the steam-distillation of fresh leaves. The physico-chemical characteristics of the oil are as follows: sp. gr.^{25°}, 0.808; n^{25} , 1.4900; [α], +1.05°; ester val., 24.6; ester val. after acetylation, 71.6; acid val., 0.4; sap. val., 25.0; sol. in 10 parts of 90% alcohol. The oil tends to resinify on keeping. It contains the following constituents: ocimene, 35; α-terpinene, 20; dipentene, 5; p-cymene, 5; aromadendrene, 2; alcohols (heptyl alcohol, methyl heptanol and hexyl alcohol), 25; and unidentified substances, 8% (Sharma *et al.*, *J. sci. industr. Res.*, 1953, 12B, 243; Rao, *J. Indian Inst. Sci.*, 1932, 15A, 71; Finnemore, 329).

The fruit yields 36.5% of a fat containing a high proportion of trilaurin. The fat expressed from the kernels (64% of the weight of fruit) is of dark colour and is solid at room temperature. A sample of stored oil had the following physico-chemical constants: m.p., 35-36°; sp. gr.^{30°}, 0.9230; n^{40} , 1.4451; iod. val., 15.1; sap. val., 28.6; ester val., 171.66; acid val., 86.94; Hehner val., 82.35; acet. val., 16.74; and unsapon. matter, 1.3%. The proportion of fatty acids in the fat were as follows: lauric, 76.7 and oleic, 21.9%. A sample of fresh kernel oil from fruits obtained from Ceylon (yield of oil, 66%; iod. val., 22.5; sap. val., 223.3; acid val., 10.4; and unsapon. matter, 2.1%) had the following fatty acid composition: capric, 3; lauric, 85.9; myristic, 3.8; oleic, 4.0; and linoleic, 3.3%; saturated glycerides, 87%; and trilaurin, 66%. The fruit coat gave 27% oil (iod. val., 69.0; sap. val., 202.2; acid val., 162.0; and unsapon. matter, 4.3%) with the following fatty acid composition: lauric, 10.2; palmitic, 28.2; stearic, 3.1; hexadecenoic, 4.6; oleic, 43.6; and linoleic, 10.3%. The kernel oil is a rich source of lauric acid and may be used as a starting material for the production of detergents like sodium lauryl sulphate (Eckey, 442; Narang & Puntambekar, *J. Indian chem. Soc.*, 1957, 34, 136; Puntambekar, *Indian For.*, 1934, 60, 707; Gunde & Hilditch, *J. chem. Soc.*, 1938, 1610).

The tree yields an attractive, greyish to light brown wood, close- and even-grained, moderately hard and heavy (wt., 753 kg./cu. m.). The wood seasons well and is durable and resistant to insect attack. It is used for house construction, rafters and furniture; it is suitable for turnery and inlay and decorative work

(Gamble, 573; Krishnamurti Naidu, 83; Howard, 310; Lewis, 329; Rao, loc. cit.).

The bark and leaves of the tree resemble those of *Cinnamomum* sp. and are reported to be used as adulterant of the latter. The root and bark are applied to bruises and eruptions. They give positive tests for alkaloids. The bark contains 7% tannin [Rao, loc. cit.; Krishnamurti Naidu, 83; Burkill, II, 1541; Webb, *Bull. sci. industr. Res. Org. Aust.*, No. 268, 1952, 47; Edwards et al., *Indian For. Rec.*, N.S., *Chem. & Minor For. Prod.*, 1952, 1(2), 153].

N. umbrosa (Nees) Gamble syn. *Litsea umbrosa* Nees

D.E.P., V, 84; Fl. Br. Ind., V, 179.

KASHMIR—*Chirindi*; PUNJAB—*Chirudi, chindi*; KUMAUN—*Chirara, cher*; NEPAL—*Pooteli*; KHASI—*Dieng-soh-tartiat*.

An evergreen shrub or a small tree, up to 9 m. in height and 1.4 m. in girth, found throughout the Himalayas, Khasi hills and Manipur, at altitudes of 900-2,700 m. Bark brownish; leaves elliptic to oblong-lanceolate: flowers in dense, sessile clusters, yellowish, fragrant; fruit globose or oblong-ovoid, c. 1.25 cm. long, purplish when young, black when ripe.

The tree yields a brownish yellow to grey wood, generally with dark striations towards the centre, lustrous when freshly exposed, becoming dull with age, smooth, straight-grained, fine- and even-textured, moderately hard, strong and light (sp. gr., c. 0.47; wt., 481 kg./cu. m.). It is liable to split and develop surface cracks during seasoning; green conversion and stacking in open piles are recommended. The wood is suitable for interior construction work (Pearson & Brown, II, 855-57).

The fruits yield an oil used for burning and also as an application for skin diseases. The leaves are used as fodder in the hilly areas of Punjab, but the fodder is of medium or poor quality (Gupta, 402; Laurie, *Indian For. Leafl.*, No. 82, 1945, 15).

NEONAUCLA Merril (*Rubiaceae*)

Fl. Br. Ind., III, 26.

A small genus of trees distributed from the Indo-Malaysian region to the Pacific. Three species are found in India.

N. gageana (King) Merrill syn. *Nauclaea gageana* King is a large tree, up to 36 m. in height and 3 m. in girth, found in the Andaman Islands. It yields a useful timber resembling that of *Adina cordifolia* (q.v.) (Parkinson, 186).

N. purpurea (Roxb.) Merrill syn. *Nauclea purpurea* Roxb. (MAR.—*Phuga, biloor*; TEL.—*Bagada*; KAN.—*Ahuan*; BOMBAY—*Dev-phanas*) is a small or medium-sized tree found in the greater part of Deccan Peninsula up to an altitude of 900 m. The wood is yellow or reddish, even-grained, smooth, moderately hard and heavy (wt., c. 737 kg./cu. m.); it makes a handsome furniture timber (Gamble, 405; Talbot, II, 90).

Nepal Cardamom — see *Amomum*

Nepal Paper — see *Daphne*, *Edgeworthia*

Nepal Sassafras — see *Cinnamomum*

NEPENTHES Linn. (*Nepenthaceae*)

D.E.P., V, 345; Fl. Br. Ind., V, 68.

A genus of prostrate, scandent or rarely erect insectivorous herbs, subshrubs or shrubs distributed from southern China to north-eastern Australia and New Caledonia, and extending westwards to Seychelles and Malagasy (Madagascar). One species, *N. khasiana*, occurs in Assam.



FIG. 6—NEPENTHES KHASIANA—WITH PITCHERS

NEPENTHES

The species of *Nepenthes* constitute the Pitcher Plants, characterized by the peculiar pitcher-like appendages terminating the leaves used by the plants for catching insects. The pitchers vary greatly in shape and size, and are often brightly coloured, being red, green, purple, yellow or various combination of these colours. Numerous nectar glands are studded on the inner lid surface and at the entrance to the pitcher (rim) : the interior of the lower part of the pitcher also bears numerous glands which secrete an enzyme. Insects which are attracted by their colour and nectar glands, slip down into the liquid at the bottom of the pitchers, where their bodies are digested and the products of digestion absorbed by the plant (Chittenden, III, 1363 ; Bailey, 1947, II, 2122-23 ; Encyclopaedia Britannica, XVII, 970 ; Neal, 326).

Pitcher plants thrive best in moist atmosphere, where temperature ranges from 21° to 30° or a few degrees less in winter. They make excellent basket plants when planted in a compost of equal parts of peat, leaf mould and sphagnum. They are propagated by cuttings, layers and seeds. The stems of pitcher plants are very tough and are used for rough cordage throughout Malaysia (Firminger, 383 ; Bailey, 1949, 452 ; Burkhill, II, 1543).

N. khasiana Hook. f. (KHASI—*Tiew-rakot*), a short stout, prostrate undershrub with sub-cylindric pitchers is found in Garo, Khasi and Jaintia hills in Assam up to 1,200 m. The pitcher of the plant, with insects, is rubbed into a paste and mixed with water, given to cholera patients. The liquid formed in the pitcher is used locally as a remedy for urinary troubles when administered orally, and for redness and itching of the eye if used as eye drops (Fl. Assam, IV, 25 ; Rao, Pakist. J. sci. industr. Res., 1961, 4, 219).

NEPETÀ Linn. (*Labiatae*)

A large genus of perennial or annual herbs found in Europe, N. Africa and Asia. About 30 species occur in India.

N. cataria Linn. CATNIP, CATMINT

Fl. Br. Ind., IV, 662 ; Mukerjee, Rec. bot. Surv. India, 1940, 14(1), 132 ; Blatter, II, 116, Pl. 52, Fig. 5.

An erect, hoary, pubescent, perennial herb, 60-100 cm. high, found in western temperate Himalayas from Dalhousie to Kashmir, up to an altitude of 1,500 m. Leaves ovate, coarsely crenate ; flowers white, dotted with purple ; nutlets broadly oblong, smooth, brownish black.

N. cataria is grown for its scented leaves and flowering tops used for flavouring purposes and in medicine. It is propagated by seeds or root divisions and thrives best on well-drained, moderately rich garden loam. Leaves and flowering tops are harvested when the plants are in full bloom (Sievers, Fmrs' Bull. U.S. Dep. Agric., No. 1999, 1948, 38).

Catnip possesses a strong, somewhat aromatic and disagreeable odour suggestive of a mixture of mint and pennyroyal, and a warm, bitterish and camphoraceous taste. Leaves and shoots are used for flavouring sauces and cooked foods ; dried leaves are used in herb mixtures for soups and stews. Leaves and flowering tops are considered carminative, tonic, diaphoretic, refrigerant and soporific. Leaves are chewed to relieve toothache (Bentley & Trimen, III, 209 ; Muenscher & Rice, 119 ; Wren, 72 ; Steinmetz, II, 315 ; U.S.D., 1955, 1619).

A volatile oil (Oil of Catnip) is obtained by steam-distillation of the herb in 0.3% yield. The oil has the characteristic odour of the herb and its physico-chemical properties vary within the following limits : sp. gr.^{15°}/_{15°}, 0.986-1.083 ; n^{20} , 1.4872-1.4913 ; $[\alpha]_D$, +1.3° to +13.3° ; acid val., 292.1-311.7 ; usually sol. in 0.5-1 vol. and more of 80% alcohol, often with slight opalescence and in some cases with separation of paraffins. The principal constituents of the American oil are nepetalactone ($C_{10}H_{14}O_2$, b.p. 67-70°) and nepetalic acid ($C_{10}H_{16}O_3$, m.p. 74-75°) ; nepetalic anhydride ($C_{20}H_{30}O_3$, m.p. 139-40°), β -caryophyllene, and two unidentified substances, probably an ether and an ester, are also present. A sample of oil from Sicily contained carvacrol, besides an alcohol, nepetol, and traces of pulegone and thymol. Oil of catnip is used as an efficient lure for trapping wild animals of the cat family ; it is used after dilution with petrolatum. Nepetalactone is the component, the odour of which makes the plant so attractive to the animals. The oil has a limited demand and has been replaced by cheaper synthetic substitutes (Guenther, III, 434-35 ; II, 607, 613, 690 ; Chem. Abstr., 1942, 36, 5800 ; Sievers, loc. cit.).

N. ciliaris Benth.

D.E.P., V, 345 ; Fl. Br. Ind., IV, 661 ; Mukerjee, Rec. bot. Surv. India, 1940, 14(1), 131 ; Kirt. & Basu, Pl. 765C.

PUNJAB—*Zufa yabis*.

An erect, slender, softly tomentose herb, 30-100 cm. high, found in western temperate Himalayas from Garhwal to Kashmir, at altitudes of 1,800-2,400 m.

Leaves ovate-obtuse, crenate; flowers lilac; nutlets broadly ellipsoid, dark brown.

The dried leaves and flowering tops of the plant, on steam-distillation, yield an essential oil (yield, 0.54%; sp. gr.^{20°}, 1.061; and n^{20} , 1.499). A sherbet (syrup) prepared from the leaves and seeds is reported to be useful in coughs and fevers [Handa *et al.*, *J. sci. industr. Res.*, 1957, **16A**(5), suppl., 18; Kirt. & Basu, III, 2003].

N. hindostana (Roth) Haines syn. *N. ruderale* Buch.-Ham.

D.E.P., V, 346; Fl. Br. Ind., IV, 661; Mukerjee, *Rec. bot. Surv. India*, 1940, **14**(1), 133.

PUNJAB—*Billilotan, badranj boyo, bebrang khatai*.

An erect or ascending herb, 15–40 cm. high, found in Punjab, upper Gangetic plain, Bihar, Bengal, Rajasthan, Deccan and Konkan, ascending to 2,400 m. in the Himalayas. Leaves broadly ovate or orbicular, crenate; flowers blue-purple; nutlets broadly oblong, brown with white dots.

The leaves of the plant, on steam-distillation, yield a pale yellow oil with the following characteristics: sp. gr.^{22°}, 0.8684; n^{22} , 1.4775; $[\alpha]^{20°}$, +16.08°; acid

val., 8.5; sap. val., 40.8; and sap. val. after acetylation, 81.7. The oil contains: *d*- and *l*-limonene, 20.8%; methyl heptenone, 9.1; citronellal, 17.8; *l*-menthone, 5.5; citronellol, 13.0; geraniol, 7.6; geranyl acetate, 13.2; and unidentified sesquiterpenes, 4.5%. The oil appears to be somewhat similar in composition to the oils obtained from various lemongrasses (Tayal & Dutt, *Proc. nat. Acad. Sci. India*, 1940, **10A**, 79).

The plant is reported to be a cardiac tonic and is used in fevers. In Nepal, it is used internally as a remedy against gonorrhoea. A decoction of the plant is used as a gargle for sore throat (Kirt. & Basu, III, 2004).

N. elliptica Royle ex Benth. (PUNJAB—*Tukhmma-langa*) is a small ascending or flexuous herb, 30–60 cm. high, found in western temperate Himalayas, from Kashmir to Kumaun, at altitudes of 1,500–2,700 m. An infusion of the seeds of the plant is used in dysentery (Kirt. & Basu, III, 2002).

N. floccosa Benth. (LADAKH—*Chongmonga*) is a woolly herb, c. 30 cm. high (sometimes up to 100 cm.), found in Kashmir and Ladakh at altitudes of 2,500–6,000 m. The plant is browsed by goats and sheep (Stewart, 170).

NEPHELUM Linn. (*Sapindaceae*)

A small genus of trees distributed in the Indo-Malaysian region. Two species occur in India, of which one, *N. lappaceum*, bears edible fruits. A few other species, previously included under this genus, have been transferred to *Euphoria* and *Litchi*.

N. lappaceum Linn. RAMIBUTAN, RAMIBOOTAN

D.E.P., V, 346; Fl. Br. Ind., I, 687; Ochse *et al.*, I, 730.

A medium-sized tree, 15–25 m. high, native of Malaysia and introduced into India and other tropical countries. A few trees are grown in Kallar on the lower slopes of Nilgiris. Bark dark brownish grey; leaves pinnate; leaflets elliptic, obovate; flowers polygamous, small, white, in panicles; fruit globose or ovoid, 3.5–8 cm. × 2–5 cm., densely covered with soft, fleshy, yellow to bright red spines; pericarp thin, leathery, easily torn off; seeds oblong, 2.5–3.5 cm. long, arillate; aril white or rose-tinted, translucent, juicy, acidulous.

N. lappaceum is cultivated throughout Malaya where numerous horticultural types are known; about eleven of them have been selected for cultivation. The plant thrives in humid, tropical climates,



FIG. 7—NEPETA HINDOSTANA—FLOWERING BRANCH

*Horticulturist, Dep. Agric., Madras*FIG. 8—*NEPHELIUM LAPPACEUM*—FRUITING BRANCH

below an altitude of 300 m., with a minimum rainfall of 250–300 cm. evenly distributed throughout the year ; it needs a rich, well-drained sandy loam or clay loam, high in organic matter. It is propagated by seeds but vegetative propagation by layering, inarching and budding is recommended, since propagation by seeds gives rise to staminate and often unproductive trees. Vegetative propagation by marcottage using improved techniques for handling young marcots has also proved successful. Trees are planted 6.0–7.5 m. apart in Kallar. They come into bearing in about 6 years of planting and the fruits are in season from September to November. An individual tree yields c. 9 kg. of fruits per year (Chandler, 318 ; Whitehead, *Malay. agric. J.*, 1959, 42, 53 ; Milsum, *World Crops*, 1960, 12, 254 ; Ochse *et al.*, I, 734 ; Naik, 406–07 ; Popenoe, 329).

Rambutan fruit resembles litchi, but differs in having long fleshy spines which are coloured. The arils (c. 32% of the fruit) are sweet and pleasant, and consumed fresh ; they are excellent especially when

taken mixed with other fruits. They are also used as compote. Analysis of arils (from Ceylon) gave the following values : moisture, 82.3 ; protein, 0.46 ; ether extr., 0.07 ; total carbohydrates, 16.02 ; reducing sugars, 2.9 ; sucrose, 5.8 ; fibre, 0.24 ; and mineral matter, 0.91% : calcium, 10.6 ; phosphorus, 12.9 ; and vitamin C, 30 mg./100 g. The pericarp contains tannin and a toxic saponin (Naik, 406 ; Popenoe, 328 ; Ochse *et al.*, I, 733–35 ; Joachim & Pandittesekere, *Trop. Agriculturist*, 1943, 99, 14 ; Wehmer, II, 732).

The seed kernel, forming c. 92% of the seed (wt. of seed, 1.4–2.0 g.), yields 37–43% of a solid fat, Rambutan Tallow, similar to cacao butter. It is hard and white at ordinary temperatures and on heating turns into a yellow, pleasant smelling oil. The characteristics of the fat are as follows: sp. gr. $\frac{99}{15.5}$, 0.859–0.863 ; n^{20} , 1.458–1.459 ; acid val., 0.5–5.0 ; sap. val., 193–195 ; iod. val., 39–44 ; and unsapon. matter, 0.5% ; m.p., 38–42° ; and titr., 57°. The component fatty acids of the oil are: palmitic, 2.0 ; stearic, 13.8 ; arachidic, 34.7 ; oleic, 45.3 ; and eicosenoic, 4.2% ; rambutan tallow contains 1.4% fully saturated glycerides ; the mono-oleodisaturated (probably oleostearo-arachidin and some oleodiarachidin), and dioleomonosaturated (stearo- or arachido-diolin and probably some oleo-eicoseno-saturated) glycerides are respectively 43 and 55%. The fat is remarkable for the large percentage of arachidic acid it contains. It is reported to be edible and is suitable for making soaps and candles. The fat is hardly likely to attain any economic importance as the seeds are available only for a short period during the year (Eckey, 625–27 ; Burkill, II, 1545 ; Hilditch, 1956, 359).

The wood is hard and heavy, red to reddish white or somewhat brown and liable to split during drying ; it is suitable for general construction, but since the trees are grown for fruit, they are rarely available for timber (Burkill, II, 1543, 1546 ; Desch, 1954, II, 531).

The fruit is considered astringent, stomachic and anthelmintic. Seeds are bitter and narcotic ; they are sometimes eaten after roasting. Leaves are used in poultices for headache (Kirt. & Basu, I, 639 ; Burkill, II, 1545–46 ; Ochse *et al.*, I, 735 ; Burkill & Haniff, *Gdns' Bull.*, 1929–30, 6, 187).

Nephelium spp.—see *Euphoria, Litchi*

Nephrite—see *Jade*

NEPHROLEPIS Schott (*Polypodiaceae*)

Beddome, *Indian Ferns*, 282.

A small genus of graceful terrestrial and epiphytic

ferns distributed throughout the tropical and sub-tropical regions of the world. Six species occur in India and a few exotics are grown in gardens.

These ferns are commonly cultivated for decorative purposes and are suitable for growing in pots and baskets. They are hardy and can be easily propagated by runners (Bailey, 1947, II, 2131-32; Chittenden, III, 1365; Haines, VI, 1193; Gopalaswamiengar, 384; Firminger, 266).

N. biserrata Schott syn. *N. acuta* Presl is a stout, tufted fern of drooping habit with erect, stoloniferous rhizome and long pinnate fronds found in North India, Maharashtra and South India. The rhizome of this fern is eaten in New Guinea and the young shoots in Java (Blatter & d'Almeida, 160; Chittenden, III, 1366; Burkill, II, 1549).

N. cordifolia Presl is an erect, tufted wiry fern with tuberous rhizome and long pinnate fronds found throughout India ascending up to 1,500 m. A decoction of the fresh fronds is given as a drink for coughs (Quisumbing, 66).

NEPTUNIA Lour. (*Leguminosae*; *Mimosaceae*)

A small genus of prostrate or floating herbs or undershrubs distributed in North and South America, Africa, tropical Asia and Australia. Three species are found in India of which one is introduced.

N. oleracea Lour. syn. *N. prostrata* Baill.

D.E.P., V, 348; III, 318; Fl. Br. Ind., II, 285.

HINDI—*Lajalu*; BENG.—*Pani-najak*; TEL.—*Neeru thalavapu, nipayam*; TAMI.—*Sadai, sundaikkirai*; MAL.—*Nittitoddavaddi*.

PUNJAB—*Lajalu, panilajak*; BOMBAY—*Panilajak*.

An annual floating aquatic herb common in marshes, flooded rice fields, sides of jheels, tanks, lakes and other stagnant waters throughout the greater part of India. Leaves bipinnate: leaflets small, sensitive; flowers minute, yellow, in axillary heads; pods oblique oblong; seeds 6-9, slightly compressed, brown.

The young ends of the stem are eaten as pot-herb and the pods sometimes as vegetable. The plant is considered refrigerant and astringent. In Malaya, the juice of the stem is squeezed into the ear to cure earache. Root is used in the late stages of syphilis (Kirt. & Basu, II, 904; Burkill & Haniff, *Gdns' Bull.*, 1929-30, 6, 197; Burkill, II, 1549).

N. triquetra Benth. is a low diffuse, slender, perennial herb found in upper Gangetic plain, Chota Nagpur, coastal Andhra, Kerala, Konkan, Deccan

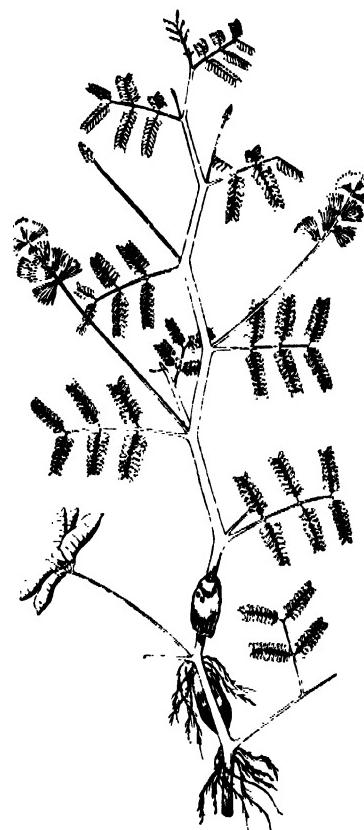


FIG. 9—NEPTUNIA OLERACEA—IN FLOWER AND FRUIT

and Gujarat. The leaves of the plant, boiled in oil, are used by the Mundas for headache (Bressers, 57).

NERIUM Linn. (*Apocynaceae*)

A small genus of shrubs distributed in the Mediterranean region and sub-tropical Asia. Three species are found in India of which one is introduced.

Commonly known as Oleanders, the plants are grown as ornamental shrubs for their showy flowers. There are numerous varieties under cultivation with single or double flowers, ranging in colour from pure white through pink to crimson. They are propagated by cuttings or layers. Oleanders are poisonous (Bailey, 1947, II, 2138-39; Chittenden, III, 1368; West & Emmel, *Bull. Fla agric. Exp. Sta.*, No. 510, 1952, 32).

**N. indicum* Mill. syn. *N. odoratum* Soland. INDIAN OLEANDER, SWEET-SCENTED OLEANDER

D. E. P., V, 348, 462; I, 167, 432; C.P., 49; Fl. Br. Ind., III, 655.

* This species differs from *N. oleander* (q.v.) only in bearing fragrant flowers; some authors regard it as a variety of the latter.

NERIUM

HINDI—*Kancer, karber, kuruvira*; BENG.—*Karabi*; MAR.—*Kanher, kaneri*; GUJ.—*Kagaer*; TEL.—*Ganneru, kastoori patelu*; TAM.—*Arali*; KAN.—*Kanagalu*; MAL.—*Areli*; ORIYA—*Konero, korobiro*.

MUNDARI—*Kanaili ba*; SANTAL—*Rajbaka*.

A large evergreen shrub with milky juice found in the Himalayas from Nepal westwards to Kashmir up to 1,950 m. and in upper Gangetic plain and Madhya Pradesh; it is found as an escape in many other States. Leaves mostly in whorls of 3, sometimes 2, linear-lanceolate, acuminate, coriaceous; flowers white, rose or red, in terminal cymes, fragrant; fruit a follicle, 15–23 cm. long, connate; seeds numerous, small, tipped with coma of light brown hairs.

N. indicum is frequently grown in gardens throughout India for its fragrant, showy flowers; it is also grown as screen or hedge. The plant flowers in April–June, often throughout the year, and fruits appear in the cold season (Bor & Raizada, 200).

All parts of the plant are poisonous. Roots, bark and seeds contain cardio-active glycosides, formerly designated as neriodorin ($C_{22}H_{32}O_7$, m.p. 86–87°), neriodorein ($C_{23}H_{34}O_{11}$, m.p. 106–07°) and karabin ($C_{21}H_{44}O_6$); neriodorin and karabin were reported to have a paralysing action on the heart, like digitalin, and a stimulating action on the spinal cord, like strychnine; neriodorein was less active. More recent investigations on the bark of the plant have revealed the presence of several glycosides with digitalis-like

activity (Table 1); the bark also contains scopoletin and scopolin. Occurrence of small quantities of a tannin (m.p. 240°), a deep red colouring matter (m.p. above 250°), an essential oil, a crystalline wax (m.p. 97°) which appears to be carnaubyl coccinate, a phlobaphene (m.p. 120–22°) and a yellow fixed oil is reported in the bark (Chopra, 1958, 515, 568; Modi, 677; Schindler, 145; Rangaswami & Reichstein, *Helv. chim. acta*, 1949, 32, 939; Rittel & Reichstein, ibid., 1954, 37, 1361; Rittel et al., ibid., 1953, 36, 434; Pendse & Dutt, *Bull. Acad. Sci. Unit. Prov.*, 1933–34, 3, 209).

The principal cardio-tonic substance present in the leaves is oleandrin ($C_{32}H_{48}O_6$, m.p. 250° decomp.), which is also the active principle of the leaves of *N. oleander* (q.v.); ursolic acid, oleanolic acid, neriodin (m.p. 238–39°), nerium D (m.p. 235–38°) and an unnamed principle (m.p. 122–23°; m.l.d. for cat, 0.44 µg./g. body wt.) are also present. Oleandrin gives on hydrolysis the aglycone acetylgitoxigenin and the sugar oleandrose (2:6-dideoxy glucose). The action of neriodin is similar to that of oleandrin; it is twice as active as digitoxin. Processes have been patented for the extraction of cardio-active principles from leaves. The leaves contain also rutin, adynerin (present also in *N. oleander*), nerium E (16-diacetyl-anhydro-oleandrin, $C_{30}H_{44}O_7$, m.p. 222–24°) and nerium F (16-anhydrodigitoxigenin, $C_{23}H_{32}O_6$, m.p. 245–47°); adynerin and nerium E are inactive

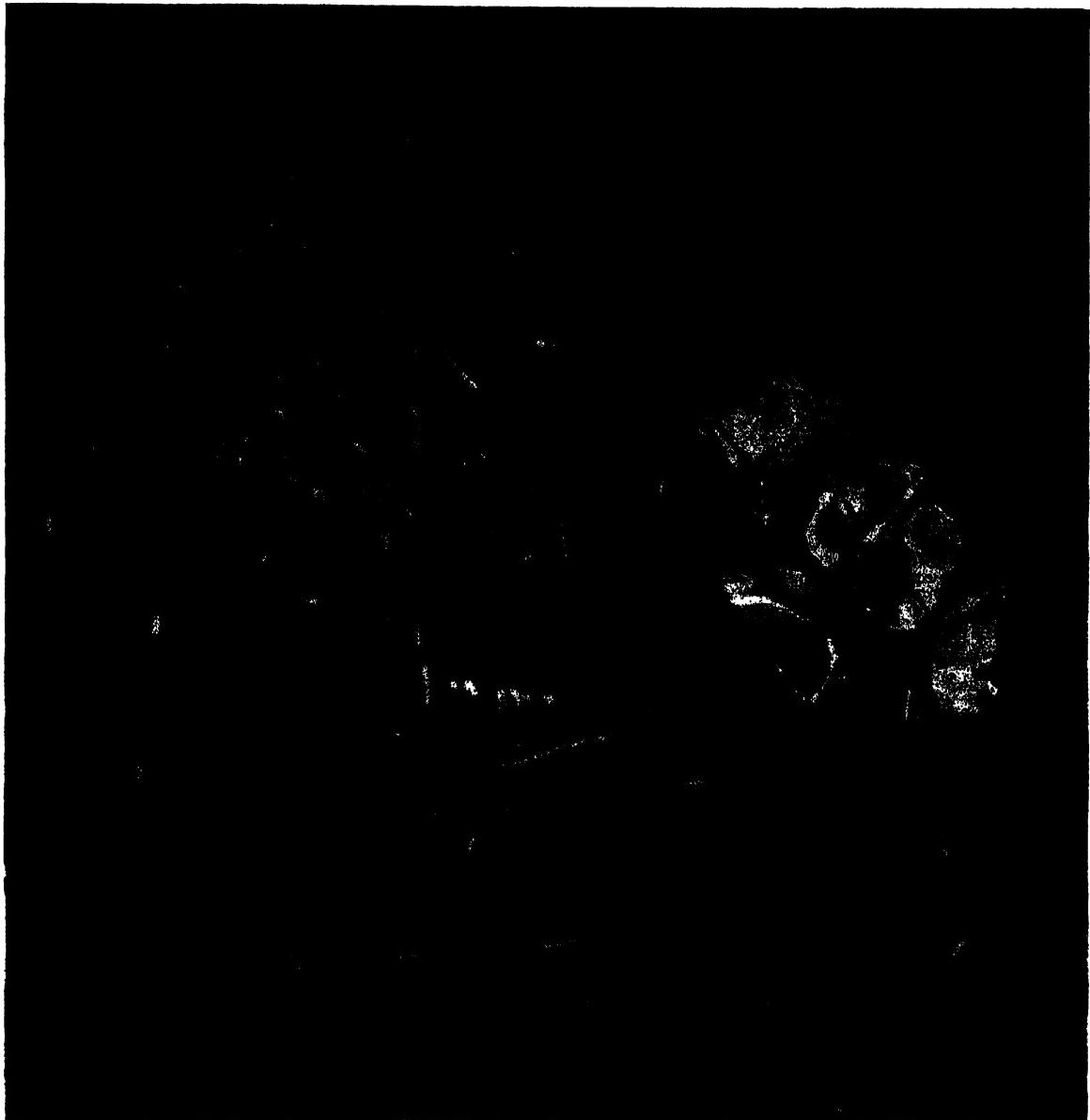
TABLE I—GLYCOSIDES FROM THE BARK OF NERIUM INDICUM*

Glycoside	Constitution	Mean lethal dose for cat (mg./kg. body wt.)
Odoroside A ($C_{30}H_{44}O_6$, m.p. 183°/198°)	Digitoxigenin-β-D-diginoside	0.19
Odoroside B ($C_{30}H_{44}O_6$, m.p. 150°/200°)	Uzarigenin-β-D-diginoside	2.10
Odoroside D ($C_{36}H_{56}O_{12}$, m.p. 219°/254°)	Digitoxigenin-β-D-glucosido-β-D-diginoside	0.59
Odoroside F ($C_{36}H_{56}O_{13}$, m.p. 298°)	Digitoxigenin-β-D-glucosido-β-D-digitaloside	..
Odoroside G ($C_{44}H_{64}O_{10}$, m.p. 282°)	Digitoxigenin-β-D-glucosido-β-D-glucosido-monoacetyl-β-D-digitaloside	0.62
Odoroside H ($C_{30}H_{44}O_6$, m.p. 236°)	Digitoxigenin-β-D-digitaloside	0.20
Odoroside K ($C_{42}H_{64}O_{11}$, m.p. 196°/242–65°)	Uzarigenin-β-D-glucosido-β-D-glucosido-β-D-diginoside	4.74
Odorobioside K ($C_{36}H_{56}O_{12}$, m.p. 178°/220–55°)	Uzarigenin-β-D-glucosido-β-D-diginoside	2.29
Odoroside L (monoacetate: $C_{34}H_{48}O_{10}$, m.p. 178°)	Decomposes to D-digitalose and a derivative of 16-anhydrodigitoxigenin	
Odoroside M (monoacetate: $C_{34}H_{48-50}O_{10}$, m.p. 219°/230°)	An isomer of L	

The mean lethal dose for digitoxin is 0.3–0.42 mg./kg.

The substance originally named odoroside C was shown to be an impure odoroside D; similarly, odoroside E was a mixture of odoroside F, digitalinum verum-16-monoacetate and 16-anhydrodigitalinum verum; odoroside J was a mixture of odoroside L and M. Odoroside D gives odoroside A on hydrolysis with the enzyme from the seeds of *Adenium multiflorum*; similarly, odoroside K gives odoroside B; and odoroside F gives odoroside H.

* Rangaswami & Reichstein, *Pharm. Acta Helv.*, 1949, 24, 159; *Helv. chim. acta*, 1949, 32, 939; Rheiner et al., ibid., 1952, 35, 687; Rittel et al., ibid., 1953, 36, 434; Rittel & Reichstein, ibid., 1953, 36, 554, 787; 1954, 37, 1361.



NERIUM INDICUM (RED AND WHITE TYPES) — IN FLOWER

(Heilbron & Bunbury, IV, 19; *Chem. Abstr.*, 1959, 53, 22262; 1952, 46, 4183; 1951, 45, 9068; 1950, 44, 1977; 1953, 47, 1898, 1844, 4043; 1955, 49, 4233, 13512, 13605).

Alcoholic extracts of root, stalk, leaf and flower show antibacterial activity against *Micrococcus pyogenes* var. *aureus* and *Escherichia coli*. Root extracts are toxic to black carpet beetle larvae. Kerosene extracts of fresh flowers are active against rice weevil, *Sitophilus oryzae*; they are more effective than pyrethrum extracts. Alcoholic extracts of dried flowers are pink in colour. The colour changes to green on addition of alkali and reappears when acid is added. The change of colour occurs in the pH range 5.4–5.7 and its use as an indicator in volumetric analysis for the titration of moderately strong acids has been suggested. The ash of the plant (3.6%) is rich in soluble potassium salts (George *et al.*, *J. sci. industr. Res.*, 1947, 6B, 42; Jacobson, 20; Rao, *Econ. Bot.*, 1957, 11, 274; Sanyal & Das, *J. Instn Chem. India*, 1956, 28, 153; Mata Prasad & Dange, *Indian For. Leafl.*, No. 95, 1947, 5).

The root of the plant is bitter and poisonous. It contains a bitter glucoside, a phenolic compound (m.p. 140–41°), a small amount of an essential oil (d_{40}^{20} , 0.8660; n_{D}^{20} , 1.40315; $[\alpha]_D$, -4.08°), and resinous matter (7.5%) from which an alcohol ($C_{30}H_{40}O$, m.p. 184–85°) resembling α -amyrin has been isolated. It is used externally as a resolvent and attenuant. A paste of the root is used as an external application in haemorrhoids, chancres and ulcerations. An oil extracted from the root bark is used in skin diseases of a scaly nature. Fresh juice of leaves is dropped into the eyes for inducing lachrymation in ophthalmia. The fragrant flowers of the plant are used as votive offerings in temples and made into garlands (Kirt. & Basu, II, 1585; Gadre, *J. Indian Inst. Sci.*, 1914–18, 1, 181; Nadkarni, I,

N. oleander Linn. OLEANDER, ROSE BAY
Chittenden, III, 1368; Bailey, 1947, II, Fig. 2476.

An evergreen, glabrous shrub, up to 6.0 m. high, native of the Mediterranean region and extending as far as Iran. It is often grown in Indian gardens for ornament and also as fence and wind-break. Leaves opposite in pairs or in whorls of 3, narrowly oblong-lanceolate, 6–20 cm. x 1–3 cm.; flowers salver-shaped, pink or white, scentless, in terminal cymes; follicles 8–15 cm. long, straight, appressed, longitudinally striate, yellowish green to light brown; seeds numerous with a tuft of brown hairs.

Leaves, flowers and stem bark of *N. oleander* possess cardio-tonic properties. Leaves contain the glycosides, oleandrin, nerifolin ($C_{30}H_{40}O_6$, m.p. 218–25°), adynerin ($C_{30}H_{40}O_7$, m.p. 234°) and neriantin ($C_{30}H_{40}O_8$, m.p. 206–08°). The chief active principle is oleandrin; it stimulates the heart and has a pronounced diuretic effect. Nerifolin is much weaker, while adynerin and neriantin are physiologically inactive. Other glycosides (mono-, bio-, and triosides) reported to be present in the leaves are digitalinum verum, odorobiosides G and K, odoro-triosides G and K, cornerine ($C_{30}H_{40}O_9$), and 4 flavonol glycosides including rutin and kaempferol-3-rhamnoglycoside. The flavonol glycosides influence vascular permeability and possess diuretic properties. In clinical trials, cornerine has proved effective against cardiac disturbances, particularly in improving the functions of heart muscles (U.S.D., 1955, 1769; McIlroy, 82–83; Heilbron & Bunbury, III, 600–01; Schindler, 145; *Chem. Abstr.*, 1955, 49, 13512; 1960, 54, 15834; *Indian J. Pharm.*, 1957, 19, 62; *Biol. Abstr.*, 1957, 31, 1495; *Chem. Abstr.*, 1958, 52, 4018).

The bark and flowers possess cardio-tonic properties similar to the leaves. Several glycosides, digitalinum verum among them, have been identified in the flower (Hoppe, 601; *Chem. Abstr.*, 1960, 54, 15834).

The seeds contain 18 cardiac glycosides, including oleandrin, odorosides A and H, nerigoside, 16-anhydro-deacetyl nerigoside, deacetyl nerigoside and neritaloside. Hulls likewise contain a number of monosides, biosides and triosides. The seeds yield c. 17% of a fatty oil (iod. val., 89.3) consisting of 12% saturated and 88% unsaturated acids (Jager *et al.*, *Helv. chim. acta*, 1959, 42, 977; *Chem. Abstr.*, 1960, 54, 8650, 14577; Wehmer, II, 991; Chatfield, 123).

The bark contains a toxic glycoside, rosaginin. Leaves, stems and flowers contain small amounts of alkaloids. The flowers yield 0.03% of an essential oil and the leaves, 0.025% (Wehmer, II, 991; *Chem. Abstr.*, 1956, 50, 5240).

The leaves of the plant are used in cutaneous eruptions. A decoction of leaves is used to destroy maggots infesting wounds. Aqueous extracts of leaves, branches, roots and flowers are toxic to certain insects. The plant is used as rat poison in southern Europe. Honey from the nectar may also be toxic (Hocking, 149; Van Steenis-Kruseman, *Bull. Org. sci. Res. Indonesia*, No. 18, 1953, 13; Jacobson, 20; U.S.D., 1955, 1769).

NERVILIA

NERVILIA Comm. (*Orchidaceae*)

A genus of terrestrial orchids distributed from Africa to India and China, and through Malaysia to Australia. About twenty species occur in India.

N. aragoana Gaudich. syn. *Pogonia flabelliformis* Lindl.

Fl. Br. Ind., VI, 121; Blatter, *J. Bombay nat. Hist. Soc.*, 1931, 32, 35, 729.

A terrestrial orchid with sub-globose, white tubers, c. 2.5 cm. diam., and solitary ovate-acuminate leaves found in the tropical Himalayas from Garhwal eastwards at altitudes of 1,200–1,500 m.. and in Bihar, Rampa hills, Palni hills, Konkan, N. Kanara, and Travancore. The orchid bears greenish flowers and leaves appear only after the flowers have withered (Fl. Malaya, I, 104).

A decoction of leaves is used in Malaya as a protective medicine after child birth. In Guam, the tubers are chewed to allay thirst (Burkill, II, 1551).

*NESAEA Comm. ex Juss. (*Lythraceae*)

A genus of annual or perennial herbs, undershrubs or shrubs distributed in North and South America, Africa, Malagasy (Madagascar), India and Australia. Four or five species have been recorded in India, of which three are introduced and grown in gardens.

N. salicifolia H.B. & K.=*Heimia salicifolia* Link Chittenden, II, 969.

An erect much-branched shrub, 0.6–1.8 m. high, native from Mexico to Argentina and grown in Lloyd Botanic Garden, Darjeeling. Leaves linear-lanceolate to lanceolate; flowers solitary, yellow, axillary; fruit a globose or ellipsoid capsule with small seeds.

The leaves of the plant are reported to contain a bitter substance, nessin. They give positive tests for the presence of alkaloids and free triterpenes. The leaves are considered emetic, antipyretic, diuretic, laxative, vulnerary, tonic, antisiphilitic, diaphoretic and astringent. A decoction of plant, when taken internally, produces a pleasant and mild intoxication with amnesia and yellow vision (Wehmer, II, 816; Webb, *Bull. sci. industr. Res. Org. Aust.*, No. 268, 1952, 59; Simes *et al.*, *ibid.*, No. 281, 1959, 16; Hocking, 103; Uphof, 182).

* The genus *Heimia* Link & Otto has been revived to include some of the species of the genus *Nesaea*.

Nettle, Common or Stinging — see *Urtica*

Nettle, Devil or Fever — see *Laportea*

Nettle, Himalayan or Nilgiri — see *Girardinia*

Nettle Tree, Indian — see *Trema*

NEURACANTHUS Nees (*Acanthaceae*)

A small genus of herbs or undershrubs distributed in Africa, Mascarene Islands, Malagasy (Madagascar), Arabia and India. Four species occur in India.

N. sphaerostachyus Dalz.

Fl. Br. Ind., IV, 491; Bole & Santapau, *J. Bombay nat. Hist. Soc.*, 1951–52, 50, 428, Pl. 1 & 2.

MAR. *Ganthera, ghosvel*; Guj.—*Ganthera*.

A biennial or possibly perennial plant, 15–75 cm. high, with sub-sessile leaves and bright blue flowers found gregarious in the dry deciduous forests of Konkan, western ghats, Deccan and Gujarat.

The root of the plant is powdered and made into a paste which is used as a cure for ringworm; it is used also in indigestion (Kirt. & Basu, III, 1883).

New Zealand Banana — see *Feijoa*

New Zealand Flax or Hemp — see *Phormium*

NEYRAUDIA Hook. f. (*Gramineae*)

Fl. Br. Ind., VII, 305; Fl. Assam, V, 114; Bor, *Indian For. Rec., N.S., Bot.*, 1941, 2(1), 155, Pl. 40 & 41.

A very small genus of tall perennial grasses distributed in tropical and temperate Asia, Africa and Malagasy (Madagascar). Two species occur in India.

N. arundinacea (Linn.) Henr. syn. *N. madagascariensis* Hook. f. (UTTAR PRADESH—*Bichhroo, bansi, naltura*) is a tall perennial leafy grass distributed in the Punjab, tropical Himalayas ascending to 1,500 m.. hills of Assam, N. Bengal, Bihar and Kerala at an altitude of 1,800 m. Culms 2.5 m. tall, smooth; panicles 30–90 cm. long; spikelets laterally compressed, pale brown; grain linear, terete.

It is a handsome grass resembling *Phragmites* with practically no fodder value but animals eat its fresh young shoots (Burkill, II, 2186).

N. reynaudiana (Kunth) Keng ex Hitchcock syn. *N. madagascariensis* Hook. f. var. *zollingeri* Hook. f., a related species with silvery olive grey coloured panicles, is cultivated in gardens (Bailey, 1949, 158).

NICANDRA Adans. (*Solanaceae*)

A monotypic genus, represented by *N. physalodes*, native of Peru, widely distributed and naturalized in the tropics, including India.

N. physalodes (Linn.) Gaertn. **APPLE OF PERU**
D.E.P., V, 350; Fl. Br. Ind., IV, 240.

KAN.—*Neelipuddac gida*.

BOMBAY—*Ran-popati*.

An annual erect herb, 30–150 cm. high, sometimes cultivated, but often found as an escape in many parts of India; it is found in sub-temperate Himalayas, from Kashmir to Sikkim, up to 1,800 m. and also in the hilly regions of west Deccan Peninsula. Leaves ovate-lanceolate, lobed or coarsely toothed; flowers campanulate, blue or light purple, axillary; fruit a globose berry, enclosed in an enlarged 5-angled calyx; seeds many, compressed, subdiscoid.

N. physalodes occurs as a weed in some areas; it can be controlled by spraying with 2,4-D at the rate of 1.13–2.5 kg. per hectare. It is avoided by livestock.



FIG. 10—NICANDRA PHYSALODES—FLOWERING AND FRUITING BRANCH

The plant is reported to possess diuretic, anthelmintic and insecticidal properties. It is said to be used as fly poison in some parts of the United States of America; in Malagasy (Madagascar), a decoction of the leaves is used for killing head lice. The fresh herb contains 0.65% of a glycosidal bitter principle, designated nicandrin ($C_{21}H_{31}O_7$), and an alkaloid with a troponic nucleus and mydriatic action. The seeds yield a fatty oil (c. 21%; iod. val., 138.0) containing 90% liquid fatty acids; the oil is suitable for use in varnishes [Ram Gopal, *Indian Eng.*, N.S., 1954, 55, 4(10), 24; Kumar & Solomon, *Poona agric. Coll. Mag.*, 1952–53, 43(2), 63; Connor, *Bull. Dep. sci. industr. Res. N.Z.*, No. 99, 1951, 93; Kirt. & Basu, III, 1779; Jacobs & Burlage, 207; Chopra, 1958, 580; *Chem. Abstr.*, 1951, 45, 10507, 1360; 1954, 48, 4777; 1950, 44, 8681].

NICKEL ORES

Nickel is a hard, malleable, ductile metal that is markedly resistant to corrosion. It has been estimated that nickel constitutes c. 0.016% of the earth's crust. Although nickel is widely distributed in nature, the igneous rocks in which it occurs are not readily susceptible to concentration by weathering. Hence the workable deposits are restricted to a relatively few places in the world, and even in these the economic exploitation depends on the recovery of other valuable metals. The nickel content of the ores mined rarely exceeds 5%. Besides being obtained from ores treated mainly for their nickel content, some metal is also recovered during electrolytic refining of copper (Thompson, *Circ. U.S. nat. Bur. Stand.*, No. 592, 1958).

The chief nickel-bearing minerals are nickeliferous pyrrhotite, pentlandite, garnierite and niccolite. Other nickel minerals of minor importance include millerite (NiS), breithauptite ($NiSb$), chloanthite ($NiAs_{2-2.5}$), maucherite ($Ni_{11}As_8$), gersdorffite ($NiAsS$), antigorite (hydrous magnesium silicate with nickel), vermiculites (hydrous silicates of Fe, Mg, and/or Al), polydymite (Ni_3S_4), and violarite [$(Ni,Fe)_2S_4$]. A description of some of the important minerals is given below.

Nickeliferous pyrrhotite (Fe_nS_{n+1} with small amounts of nickel) is a valuable ore of nickel varying in colour from bronze yellow to copper red, and subject to speedy tarnish. It is magnetic, and contains variable amounts of dissolved sulphur. The nickel content may be due to enclosed grains of pentlandite. It occurs at times in large amounts associated with basic igneous rocks such as gabbro and norite, horn-

NICKEL ORES

blende and augite from which it has been segregated by some form of magnetic differentiation.

Pentlandite [(Fe,Ni)S and in part 2FeS.NiS, nickel 22%, sulphur 36% and iron 42%; sp. gr., 4.6–5.0; H., 3.5–4] is a brittle, opaque and non-magnetic mineral with a light bronze yellow colour and metallic lustre. It commonly occurs intergrown with pyrrhotite, and associated also with millerite, niccolite, gersdorffite, pyrite, marcasite and chalcopyrite.

Garnierite [H₂(Ni,Mg)SiO₄.nH₂O; sp. gr., 2.3–2.8; H., 2–3] is a hydrated silicate of magnesium and nickel with a very variable composition particularly as regards the nickel and magnesium. It is soft and friable with a bright apple green colour and dull lustre.

Niccolite (NiAs: arsenic 56.1% and nickel 43.9%; sp. gr., 7.33–7.67; H., 5–5.5) is a pale copper red mineral with a metallic lustre and brittle fracture. It is opaque and contains usually a little of iron, cobalt and sulphur. A part of the arsenic may sometimes be replaced by antimony and then the ore grades toward breithauptite. The mineral is commonly associated with smaltite, chloanthite, annabergite, native silver, the silver arsenic minerals, pyrite, chalcopyrite and other sulphides, quartz and barite.

Nickel ores may be classified into three principal groups, viz. sulphide, silicate (oxide), and arsenide ores. The sulphide nickel ores occur associated with basic intrusive rocks of the gabbro or peridotite types. The well-known nickel deposits in the Sudbury area of Ontario (Canada) belong to this group and the mineral is pentlandite. The silicate (oxide) ores result from the breakdown of nickel-bearing basic rocks in tropical climates which produce lateritic weathering. They are composed of intimate mixtures in varying proportions of hydrous magnesium silicate, limonite, goethite, hematite, and silica, and are generally known as silicate ore or limonite ore depending upon the low or high iron content. The largest known deposits are in New Caledonia where the chief nickel-bearing mineral is garnierite. The arsenide ores occur in small amounts in veins usually in association with copper and silver ores, and are of little commercial importance. Niccolite and chloanthite are the principal nickel-carrying arsenides.

Nickel deposits of Canada, the U.S.S.R., and New Caledonia account for over 90% of the world's annual output, and amongst these Canada's share is about 60% of the total. Nickel ores are also mined in Cuba, the United States, South Africa, Poland, Finland, and in small quantities in several other countries. No

TABLE I—WORLD PRODUCTION OF NICKEL ORES
(METAL CONTENT)*

	(Qty in thousand tonnes)				
	1957	1958	1959	1960	1961
Canada	170.5	126.6	169.2	194.6	211.4
Cuba	20.2	17.9	17.8	11.4*	7.5
New Caledonia	43.3	14.2	32.8	53.5	54.0
Poland	1.3	1.3	1.3	1.2	1.3
South Africa	4.1	2.0	2.7	3.0	2.6
United States ^b	12.1	12.7	12.6	13.3	12.5
U.S.S.R.	50.0	53.0	53.0	58.0	60.0
Others	1.5	1.3	0.6	7.0	10.7
Total	303.0	229.0	290.0	342.0	360.0

* Statist. Yearb. United Nations, 1962, 160; * Jan.–Sept.;
b including the by-product in electrolytic refining of copper.

workable deposits have so far been located in India. Table I summarizes the world production of nickel ores in recent years.

The Canadian ores of the Sudbury dist. have been the dominant factor in the nickel industry for many years. The average ore carries about 1.5% nickel and 1% copper. The deposits, which have been proved to a depth of 1,200 m., are estimated to contain reserves totalling nearly 440 million tonnes.

DISTRIBUTION

Nickel minerals have been reported from many States in the Indian Union, but there are no deposits of any commercial importance. The metal occurs in association with copper ores of the Singhbhum belt in Bihar. Some of the more promising occurrences are located in Jammu & Kashmir and Manipur.

Bihar—Nickel is a constituent of some importance in the copper ore deposits of Singhbhum dist. It is reported that pyrrhotite, which is more abundant than chalcopyrite in these areas, contains both pentlandite and violarite; millerite has also been identified. Nickel content of the Singhbhum copper ore shows large variations; a value of 0.08% for nickel (and 2% for copper) may be taken as the average. During the refining and smelting of the ore, nickel is found to be concentrated along with copper and can be recovered as a by-product (Chakravarty, *Indian Miner.*, 1959, 13, 196; Coggin Brown & Dey, 220).

A composite ore which contains recoverable quantities of nickel, besides uranium and rare elements, copper, phosphorus, sulphur, titanium and gold, has been located in the rocks of the Subarnarekha basin [Khedker, *Indian Min. J.*, 1953, 1(10 & 11), 1].

Jammu & Kashmir—Nickel-bearing minerals have been reported from Ramsu, Buniar, Khaleni, sapphire mine areas of Padar, Riasi and Dras Kargil. In Ramsu ($30^{\circ}20'15''$: $75^{\circ}12'$) the area containing nickeliferous pyrrhotite is 6.4 km. long and 0.4 km. in width. The ore occurs as disseminations and as small veins or veinlets ranging in length from a few centimetres to over a metre. The nickel content is up to 1.62%. Pentlandite is also reported to be present in the ore.

The nickeliferous pyrrhotite occurrences in the neighbourhood of the sapphire mine areas of Padar (Kishtwar) contain up to 0.305% nickel. It occurs as disseminations and as small veins, a few centimetres in length, and also forming thin layers.

In the Riasi area the presence of nickel in traces, sometimes up to 0.103%, was noticed in the copper bed of Gainta and traced up to Jungal Gali. Here the ore exists in the nickeliferous pyrrhotite as well as in the silicate form. Nickel-carrying sulphide ore has been found in the serpentine deposits of Dras Kargil area (Middlemiss, *Miner. Surv. Rep., Jammu & Kashmir*, 1929, 50-54; Badyal, *East. Met. Rev.*, 1955, 8, 625).

Madhya Pradesh—Traces of nickel are found along with cobalt in some of the manganese ores of this State. Analysis of a psilomelane sample from Sontulai ($22^{\circ}21'$: $76^{\circ}56'$) in Hoshangabad dist. showed 1.23% NiO and 0.55% CoO, whereas a specimen of conglomerate cemented by psilomelane from Pola Khal ($22^{\circ}28'$: $76^{\circ}20'$) in Dhar forest was found to contain 0.56% NiO and 0.27% CoO. Antigorite has been reported from the weathered serpentine rocks of Jobat area (Fermor, *Mem. geol. Surv. India*, 1909, 37, 114, 525; Chakravarty, loc. cit.).

Madras—Nickel occurs in the mixed sulphides ore of the Tovala taluk in Kanniyakumari dist. The ore consists of pyrrhotite, pyrite, chalcopyrite, and molybdenite. A surface sample of the ore assayed 0.64% nickel (Jhingran, *Rec. geol. Surv. India*, 1954, 80, 560).

Manipur—A suite of altered ultrabasic and basic rocks which are important from the point of copper-nickel mineralization is present in Manipur. The rocks have been traced for over a length of 72 km. from near the Indo-Burma border at the south-eastern corner of Manipur, near Kongal Thana, and continues in a general N 15° E-S 15° W to N-S direc-

tion up to a point west of Chassad, when it swerves to a NNW-SSE direction. As a result of the preliminary investigations carried out by the Geological Survey of India, it was found that nickeliferous copper sulphides and the secondary minerals are developed in the chlorite-serpentine rocks, the minerals often occupying the joint planes in the rocks and as veins, apart from being in the shape of pockets and as lenses. Two such occurrences are near Nangau ($24^{\circ}59'$: $94^{\circ}24'$) besides those near Ningthi and old copper workings near Kongal Thana. Analyses of the samples from Nangau show a copper content varying from 1.23 to 3.81% and a nickel content of 0.2%; a specimen from this area contained over 2% nickel. An ore sample from Kongal Thana yielded 1.13% nickel (Chakravarty, loc. cit.).

Geological mapping in Kwatha ($24^{\circ}20'$: $94^{\circ}17'$) and Nampesha-Humine ($24^{\circ}43'$: $94^{\circ}34'$) areas revealed that metallic nickel was dispersed in the soil in high concentrations, mostly of the order of 4,000 p.p.m. and over. Quantitative estimation by chemical assays showed that the nickel content of the soil varied up to 0.6%, a concentration high enough to justify further exploration (Dutt, *Indian Miner.*, 1960, 14, 246).

Mysore—Small quantities of nickel occur in the sulphide ores associated with the gold-bearing quartz veins of Kolar. The pyrites deposits in Karwar dist. are reported to contain about 5% nickel and 1% copper [Coggin Brown & Dey, 222: *Indian Miner. Ind.*, 1951-52, 1(7), 5].

N.E.F.A.—Nickeliferous pyrrhotite has been reported from the Subansiri frontier division (Chakravarty, loc. cit.).

Orissa—Zaratite, a basic carbonate of nickel [$\text{NiCO}_{3}\cdot2\text{Ni(OH)}_2\cdot4\text{H}_2\text{O}$], has been reported to be present in the chromite deposits of Nuasahi in Keonjhar. The chromite contains 0.3% of nickel (Coggin Brown & Dey, 224).

Rajasthan—Nickeliferous pyrrhotite has been found in the copper ores of Khetri (Jaipur dist.). Traces of nickel have been recorded in the iron ore at Bhangerh ($27^{\circ}5'30''$: $76^{\circ}21'$) in Alwar dist. Certain rocks in Pali dist. have indicated the presence of nickel (Dutta, *Rec. geol. Surv. India*, 1956, 80, 560; Roy, ibid., 1959, 86, 325; *East Met. Rev.*, 1956, 9, 233).

Nickel ores are reported to occur in Nepal, associated with cobaltite, traces of zinc and some bismuth compounds. A vein cropping out at Bhorle near Nangre ($27^{\circ}36'$: $85^{\circ}52'$) has been traced for

NICKEL ORES

750 m. and worked to a depth of 30 m. Analysis of the richest part of the ore body showed 8.2% nickel. Extensive mineralization is also reported from Maseding ($27^{\circ}44':86^{\circ}17'$) and Kapthi ($27^{\circ}44':86^{\circ}15'$) in Dist. No. 2 (*Rec. geol. Surv. India*, 1953, **79**, 213).

MINING AND TREATMENT

Nickel ores are mined by bulk open-pit and underground methods. The metal is extracted commercially from sulphide and silicate ores. In the case of sulphide ores, the crushed ground material is subjected to flotation to remove rock and float a sulphide concentrate containing the bulk of nickel, copper and iron; differential flotation afterwards gives nickel and copper concentrates. The nickel concentrate after roasting is smelted with a flux to remove all of the rock content and a part of the iron to form a matte of nickel, copper and iron sulphides, which is then bessemerized for further removal of iron and sulphur. Final separation of nickel, copper and precious metals is achieved by subjecting the bessemer matte to controlled cooling, fine grinding, magnetic separation, and differential flotation. The resulting nickel sulphide is sintered to the oxide, which may be marketed as such or reduced to metal and then refined.

The metal is refined electrolytically or by the Mond process. Electrolytic refining is conducted in a nickel sulphate-chloride electrolyte, the cathodes being stainless steel plates. The metal deposits on both sides of the cathode and is stripped off in sheets at intervals. The nickel thus produced has a purity of 99.95% and contains some cobalt. A process for recovering the metal by the direct electrolysis of nickel matte was developed recently. In the Mond process, the reduced nickel is treated with carbon monoxide at $50\text{--}60^{\circ}$ to form nickel carbonyl gas, $\text{Ni}(\text{CO})_4$, leaving the impurities as a solid residue. The gas is subsequently decomposed by heating at about 180° to produce metallic nickel and carbon monoxide. The nickel obtained has a purity of about 99.9% and is practically free from cobalt.

The silicate ore is smelted in blast furnaces to obtain a matte of mixed sulphides of nickel and iron, but as the ore does not contain sufficient sulphur, gypsum is added to the charge. The matte is bessemerized to give a low-iron nickel sulphide containing 75–80% nickel which is roasted to remove sulphur. The resulting oxide is mixed with a reducing agent and heated in horizontal retorts at $1,200\text{--}1,300^{\circ}$ to yield metallic nickel of c. 99.25%

purity (Kirk & Othmer, IX, 273–74; Johnstone & Johnstone, 396–99).

PROPERTIES AND USES

Nickel (sp. gr., 8.908; m.p., 1455°) is silvery-white, hard, malleable, and highly resistant to corrosion in many media. It has high ductility and toughness, and can be fabricated readily by all methods common to steel. It takes and retains a high polish. Nickel has the unique characteristic of improving one or more of the properties of most metals and alloys to which it is added. Indicative of the versatility of the metal is the fact that there are over 3,000 nickel alloys in current usage, containing 0.3% to slightly less than 100% nickel.

Most of the nickel of commerce is used in the form of alloy. About 60% of the metal produced in the world is said to be employed in the preparation of alloys with iron. Low-nickel steel (0.5–9% nickel) possesses high strength and toughness; it finds widespread application in motor vehicles, locomotives, tractors, excavators, oil-well castings, aircraft and marine engines, and in almost every type of machinery. Stainless steels, with 1.26% nickel, are extremely resistant to corrosion, tarnish, and stain, and are extensively used in transportation equipment, tableware and cooking utensils, and equipment for chemical, textile and paper industries and oil refineries. Still higher percentages of nickel give the heat-resistant steels for use in furnace parts, mechanical stokers and diesel engine valves. Nickel-cast irons (1–5% nickel) possess outstanding wear-resistance and hardness, and are employed in components of heavy machinery, rock and ore crushers, grinding mills and metal rollers. Many other nickel alloys with iron are made to meet special needs in mechanical engineering.

Large quantities of nickel are used for making high-nickel alloys with copper (65–70% nickel). These alloys are utilized in building components of chemical and food-processing plants and in marine and power-generating equipment. Monel metal (68% nickel, 30% copper, with some iron) has many desirable physical properties and finds wide range of industrial applications. Cupronickel alloys (25–45% nickel) are used in great quantities, particularly for condenser tubes and salt-water lines. The nickel-chromium alloys, containing 80% nickel and 20% chromium, have high scaling and electrical resistance and are used in heating elements, pyrometers, rheostats and other electrical controls. Heat-resisting

alloys (78% nickel, 14% chromium, and some iron and other elements) are specially important for high temperature service such as in jet aircraft.

Magnetic alloys (29–90% nickel), non-magnetic alloys (8–27% nickel), permanent magnet alloys (14–32% nickel), high permeability alloys (45–80% nickel), and controlled expansion alloys (30–60% nickel) have been developed for diverse applications. Nickel-bronze, an alloy of nickel with copper, is a standard form of coinage in many countries. The nickel-silvers, with proportion of nickel varying from 5 to 30%, are made into tableware and decorative articles. Many other nickel alloys are in use, and new alloys are constantly being developed.

Commercially pure nickel is used to some extent for making cooking utensils, laboratoryware and equipment for the radio industries. It is extensively employed in electroplating, whereby it provides protection against corrosion. Metallic nickel in a finely divided state finds wide application as a catalyst for hydrogenation of fats and oils (Kirk & Othmer, IX, 271, 275–79; Coggin Brown & Dey, 224–26; Encyclopaedia Britannica, XVI, 424; *Indian Miner. Yearb.*, 1959, 246).

PRODUCTION AND TRADE

There is hardly any production of nickel metal in India. It is expected to be recovered as a by-product during electrolytic refining of Singhbhum copper ores, when the plant being set up by the *Indian Copper Corporation Ltd.*, goes into production. According to the Tariff Commission Report, about 400–500 tonnes of nickel may be recovered annually from this copper refining plant. Small quantity of nickel is recovered from old quaternary alloy coins (nickel 5%) at the Indian Mint & Silver Refinery, Calcutta. Some nickel can be recovered from spent nickel catalyst which is obtained as a waste in the fat hydrogenation industry (*Tariff Comm. Rep. on the Continuance of Protection to the Non-ferrous Metals Industry*, 1957, 11).

TABLE 2—IMPORTS OF NICKEL AND NICKEL ALLOYS
(Qty in tonnes and val. in thousand Rs.)

	Qty	Val.
1957	670	6,507.3
1958	623	6,052.1
1959	839	7,941.9
1960–61	1,481	14,198.7
1961–62	1,776	15,187.2
1962–63	1,566	14,417.3

India depends entirely on imports for its nickel requirements. Table 2 gives the imports of nickel and nickel alloys (excluding stainless steel and other nickel alloys imported in the form of cutlery and other fabricated products) during 1957–63. Small quantities are also re-exported.

Nicobar Canoe Tree — see *Calophyllum*

NICOTIANA Linn. (*Solanaceae*)

A genus of large herbaceous annuals or perennials, most of them natives of North and South America and a few of Australasia. Two species, *N. tabacum* and *N. rustica*, are cultivated in India for their leaves which furnish the Tobacco of commerce; a few other species are grown as ornamentals.

The genus includes about 60 species, of which 30 are restricted to S. America and 9 to N. America; 6 species are common to both. About 15 species occur in Australia and the S. Pacific. The genus has been divided into 3 sub-genera. Sub-genus *Rustica*, to which *N. rustica* belongs, includes 9 species in 2 sections and contains the most primitive elements of the genus. Sub-genus *Tabacum*, to which *N. tabacum* belongs, includes 6 species in 2 sections. The third sub-genus, *Petunioides*, is a large one containing the remaining 45 species grouped into 9 sections. With the exception of *N. rustica* and *N. tabacum*, both of which have a chromosome complement of $n=24$, the rest of the species belonging to sub-genera *Rustica* and *Tabacum* have $n=12$; in sub-genus *Petunioides* the haploid number is either 12 or 24 in 7 sections; there is an aneuploid series below 12 in one of the remaining sections and a similar series below 24 in the other (*Indian Tob. Monogr.*, 38–42; Goodspeed, 7–8, 13–17, 332).

The genus *Nicotiana* is considered to have evolved from an ancestral reservoir of pre-*Nicotiana* elements with the basic chromosome number $n=6$, which evolved along two lines to give rise to a Cestroid complex and a Petunioid complex. The high degree of compatibility shown by even widely separated species of *Nicotiana* suggests that natural hybridization may have been an important factor in speciation. The present preponderance of species with $n=12$ (28 out of 56 species investigated) and absence of species with $n=6$ is said to be consistent with the hypothesis that allopolyploid species have a higher survival potential in changing habitats than their diploid parents. Combined morphological, distributional and cytogenetic evidence is said to

NICOTIANA

indicate the amphiploid origin and mode of evolution of present day species with $n=24$ from species with $n=12$ whose modern descendants can be identified. Thus *N. rustica* is thought to be related in amphiploidy to *N. paniculata* and *N. undulata*, and *N. tabacum* to *N. sylvestris* and a member of the section *Tomentosae*. Individuals resembling *N. rustica* and *N. tabacum* and with $n=24$ have been produced by hybridization of the concerned parent species and subsequent artificial induction of amphiploidy, thus strengthening the above view of the origin of these species (Goodspeed, 283-314; Indian Tob. Monogr., 42-43).

N. rustica Linn. TOBACCO

D.E.P., V, 352; C.P., 794; Fl. Br. Ind., IV, 245; Goodspeed, 351, Fig. 66-67.

A coarse annual, 50-150 cm. high, with a rather thick pubescent stem and slender branches; leaves petiolate, fleshy, dark green with uneven surface, up

to 30 cm. \times 20 cm., usually ovate, elliptic or cordate with unequal base; panicles short, compacted into thyrses; flowers greenish yellow, 1.2-1.5 cm. long; capsules elliptic ovoid to sub-globose, 7-16 mm. long; seeds 0.7-1.1 mm. long, dusky brown, surface fluted-reticulate, larger and about three times heavier than those of *N. tabacum*.

This species is a native of S. America with its centre of origin in north central Peru. It is apparently unknown today in the wild state and was the tobacco first grown in Virginia for export to Europe. It is supposed to have been derived as an amphidiploid from a cross between *N. undulata* and *N. paniculata*, members of two distinctly separate sections. It includes a large number of varieties or races of which the extremes are represented by var. *pavonii* Goodspeed, var. *pumila* Schrank and var. *brasiliensis* Schrank. Like *N. tabacum*, it is highly polymorphic and includes a large number of cultivated types. Some 20 types have been described in India. They have been classified under two groups on the basis of plant habit and length of internodes. The first group includes tall plants with open habit and long internodes, while the second group includes shorter plants with short internodes. The second group which consists of 15 types has been further sub-divided into three sub-groups based on the nature of inflorescence which may be (i) open with sparsely arranged flowers, (ii) semi-open with crowded flowers and (iii) compact with considerable crowding of flowers (Goodspeed, 34, 353-56; Howard & Howard, Mem. Dep. Agric. India, Bot., 1910, 3, 59; Indian Tob. Monogr., 75, 48, 50).

N. rustica is a mesophyte whose temperature and moisture requirements are precise; in this respect, it differs from *N. tabacum* which is noted for its tolerance to relatively rigorous climates and hence has practically replaced *N. rustica* in the New World. The cultivation of *N. rustica* is now confined mainly to U.S.S.R., the Balkan countries, India, Pakistan, Burma, Australia and New Zealand (Indian Tob. Monogr., 48, 45).

In India *N. rustica* is commonly known as *Vilayati* or *Calcutta*. It requires a cool climate and its cultivation is confined mainly to northern and north-eastern regions of India, viz. Punjab, Uttar Pradesh, Bihar, West Bengal and Assam. It accounts for about 10% of the total area under tobacco (Indian Tob. Monogr., 3, 46).

Rustica types are generally high in nicotine content and are used for hookah, chewing and snuff; they are not suitable for cigarettes, bidis or cigars. The



Cent. Tob. Res. Inst., Rajahmundry

FIG. 11—NICOTIANA RUSTICA (HOOKAH TYPE)—IN FLOWER

methods of cultivation of Rustica types are more or less similar to those adopted for Tabacum types (Indian Tob. Monogr., 3).

N. tabacum Linn. TOBACCO

D.E.P., V, 353; C.P., 793; Fl. Br. Ind., IV, 245; Goodspeed, 372, Fig. 74.

HINDI.—BENG., MAR. & GUJ.—*Tamaku, tambaku*; TEL.—*Pogaku*; TAM.—*Pugaiyilai*; KAN.—*Hoge-soppu*; MAL.—*Pokala*.

A stout viscid annual, 1-3 m. high, with a thick erect stem and few branches; leaves ovate, elliptic or lanceolate, up to 100 cm. or more in length, usually sessile or sometimes petiolate with frilled wing or auricle; inflorescence a panicle with distinct rachis and several compound branches; flowers light red, white or light pink in colour; fruit a capsule, narrowly elliptic ovoid or orbicular, 15-20 mm. long; seeds spherical or broadly elliptic, 0.5 mm. long, brown with fluted ridges.

N. tabacum is said to be unknown in the wild state at present; on the basis of its presumed origin in amphiploid involving the progenitors of *N. sylvestris* and a member of the section *Tomentosae* such as *N. otophora* it is suggested that its original area of natural distribution was northwestern Argentina and adjacent Bolivia, where the above two species are or were in contact with each other. It is believed to have been in cultivation in pre-Columbian times in West Indies, Mexico, Central America and northern parts of South America (Goodspeed, 34, 373, 375).

N. tabacum is much more polymorphic than *N. rustica* and includes a large assemblage of varieties, forms and suspected hybrids. Various attempts have been made to designate groupings within this assemblage to which could be referred the majority of the cultivated types. As many as 69 botanical types have been recognized in India and these have been classified under two groups. The first with seven types is characterized by petiolate leaves and the other group by sessile leaves. The second group is subdivided further into classes and sub-classes depending on the shape of the leaf, plant habit and nature of inflorescence (Goodspeed, 373; Howard & Howard, Mem. Dep. Agric. India, Bot., 1910, 3, 59; Shaw & Kashi Ram, Indian J. agric. Sci., 1932, 2, 345).

Besides *N. rustica* and *N. tabacum* which are grown solely for commercial purposes, two other species of the genus are cultivated in India for ornamental purposes. One of them is *N. alata* Link & Otto (syn. *N. persica* Lindl., *N. affinis* Hort.), a clammy glan-



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FIG. 12—NICOTIANA TABACUM (VIRGINIA TYPE)—IN FLOWER

dular pubescent herb, c. 60 cm. high, with white flowers in terminal racemes. It is a native of Brazil bearing pretty fragrant flowers which open in the evening and close in the morning. The second species, *N. plumbaginifolia* Viv., is a native of Mexico and W. Indies and occurs as a common weed in many parts of the country, especially in damp situations by roadsides. It is somewhat hairy, c. 60 cm. high, with spreading radical leaves and slender leafy stems. It is the only species of the genus that has become completely naturalized in this country.

Except *N. rustica* and *N. tabacum* which are unknown in the wild state, all the other species of *Nicotiana* are found wild. Table 1 summarizes the occurrence, distribution and economic importance of the species validly known so far.

Tobacco improvement—Tobacco is grown in India for its leaf which is used in the manufacture of cigarettes, cigars, cheroot, bidi, hookah tobacco and for purposes of chewing. Perhaps no other country in the world has such an extensive array of cultivated types or developed specialized methods of growing

NICOTIANA

TABLE 1—DISTRIBUTION, ALKALOID CONTENT AND ECONOMIC IMPORTANCE OF VARIOUS SPECIES OF NICOTIANA*

Species	Haploid chromosome number	Distribution	Important constituent alkaloids	Economic importance
Sub-genus <i>RUSTICA</i> Goodspeed				
Section <i>PANICULATAE</i> Goodspeed				
<i>N. paniculata</i> Linn.	12	Peru	Nicotine	
<i>N. knightiana</i> Goodspeed	12	Peru		
<i>N. solanifolia</i> Walp.	12	Chile	Nicotine & nornicotine	
<i>N. benavidesii</i> Goodspeed	12	Peru	Nicotine & nornicotine	
<i>N. raimondii</i> Mach.	12	Peru	Nicotine & nornicotine	
<i>N. cordifolia</i> Phil.	12	Chile (Endemic on Masafuera Is.)		
<i>N. glauca</i> Grah.	12	Argentina	Anabasine & nicotine	Poisonous to cattle, horses & sheep; useful in the breeding of disease-resistant types of tobacco
Section <i>THYRSIFLORAE</i> Goodspeed				
<i>N. thyrsiflora</i> Bitter ex Goodspeed	12	Peru		
Section <i>RUSTICAE</i> Goodspeed				
<i>N. rustica</i> Linn.	24	Cultivated	Nicotine	An important tobacco of commerce
Sub-genus <i>TABACUM</i> Goodspeed				
Section <i>TOMENTOSAE</i> Goodspeed				
<i>N. tomentosa</i> Ruiz & Pav.	12	Peru & Bolivia	Nornicotine	
<i>N. tomentosiformis</i> Goodspeed	12	Bolivia	Nornicotine & nicotine	
<i>N. atropurpurea</i> Griseb.	12	Bolivia & Argentina	Nornicotine	
<i>N. setchellii</i> Goodspeed	12	Peru		
<i>N. glutinosa</i> Lign.	12	Peru & Ecuador	Nornicotine	Useful in the breeding of tobacco types resistant to mosaic & powdery mildew
Section <i>GENUINAE</i> Goodspeed				
<i>N. tabacum</i> Linn.	24	Cultivated	Nicotine & nornicotine	Most important tobacco of commerce
Sub-genus <i>PETUNIOIDES</i> Goodspeed				
Section <i>UNDULATAE</i> Goodspeed				
<i>N. undulata</i> Ruiz & Pav.	12	Peru & Argentina	Nornicotine	
<i>N. wigandoides</i> Koch & Fintelmann	12	Bolivia	Nicotine	
<i>N. arenstii</i> Goodspeed	24	Peru & Bolivia		
Section <i>TRIGONOPHYLLAE</i> Goodspeed				
<i>N. trigonophylla</i> Dunal	12	Mexico & South-West United States	Nornicotine	Occasionally used as tobacco by Mexican Indians
<i>N. palmeri</i> A. Gray	12	South-West United States	Nornicotine	

Contd

TABLE I—*Contd.*

Species	Haploid chromosome number	Distribution	Important constituent alkaloids	Economic importance
Section ALATAE Goodspeed				
<i>N. alata</i> Link & Otto	9	Uruguay, Brazil, Argentina & Paraguay	Nicotine	
<i>N. langsdorffii</i> Weinmann	9	Brazil, Argentina & Paraguay	Nicotine & nornicotine	
<i>N. bonariensis</i> Lehm.	9	Brazil, Uruguay & Argentina	Nicotine	
<i>N. forgetiana</i> Hort. ex Hemsl.	9	Brazil		
<i>N. longiflora</i> Cav.	10	Argentina, Paraguay, Uruguay, Brazil & Bolivia		Highly resistant to anthracnose, wild fire, black fire & black shank
<i>N. plumbaginifolia</i> Viv.	10	Widely distributed in South & Central America; naturalized in India	Nornicotine & nicotine	Resistant to leaf curl & black shank
<i>N. sylvestris</i> Spegazzini & Comes	12	Argentina	Nornicotine & nicotine	
Section REPANDAE Goodspeed				
<i>N. repanda</i> Willd.	24	Southern United States & Mexico	Nornicotine & nicotine	
<i>N. stocktonii</i> Brandegee	24	Mexico (Endemic on Clarion Is.)	Nicotine & nornicotine	
<i>N. nesophila</i> Johnston	24	Mexico	Nornicotine & nicotine	
Section NOCTIFLORAE Goodspeed				
<i>N. noctiflora</i> Hook.	12	Argentina & Chile		
<i>N. petunioides</i> (Griseb.) Millan	12	Argentina & Chile		
<i>N. ameghinoi</i> Spegazzini	..	Argentina		
<i>N. acaulis</i> Spegazzini	12	Argentina		
Section ACUMINATAE Goodspeed				
<i>N. acuminata</i> (Grah.) Hook.	12	Chile & Argentina	Nicotine	
<i>N. pauciflora</i> Remy	12	Chile	Nornicotine	
<i>N. attenuata</i> Torr. ex Wats.	12	Mexico, United States & Southern Canada	Nicotine	Cultivated & used as tobacco by American Indians
<i>N. longibracteata</i> Phil.		Andes in Argentina & Chile		
<i>N. corymbosa</i> Remy	12	Chile & Argentina		
<i>N. miersii</i> Remy	12	Chile		
<i>N. linearis</i> Phil.	12	Argentina & Chile		
<i>N. spegazzinii</i> Millan	12	Argentina		
Section BIGELOVIANAE Goodspeed				
<i>N. bigelovii</i> (Torr.) Wats	24	Western United States	Nicotinè	Cultivated & used as tobacco by American Indians

Contd.

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TABLE 1—*Contd.*

Species	Haploid chromosome number	Distribution	Important constituent alkaloids	Economic importance
<i>N. clevelandii</i> Grav	24	Mexico & southern United States	Nicotine	
Section NUDICAULES Goodspeed				
<i>N. nudicaulis</i> Wats.	24	Mexico	Nornicotine & nicotine	
Section SUAVEOLENTES Goodspeed				
<i>N. suaveolens</i> Lehm.	16	South-East Australia	Nornicotine & nicotine	
<i>N. maritima</i> Wheeler	16	South-East Australia	Nornicotine	
<i>N. velutina</i> Wheeler	16	South-East to central Australia	Nornicotine	Utilized sometimes as tobacco by aborigines ; suspected of poisoning stock
<i>N. gosei</i> Domin	18	Central Australia	Nicotine	Considered to be a powerful narcotic; chewed by natives as narcotic & smoked as tobacco ; poisonous to cattle & toxic to aphids
<i>N. excelsior</i> Black	19	South Australia		Used by natives for its narcotic properties
<i>N. megalosiphon</i> Heurck & Muell. Arg.	20	Eastern Australia		Highly resistant to nematodes
<i>N. exigua</i> Wheeler	16	Australia (Queensland)	Nornicotine & nicotine	
<i>N. goodspeedii</i> Wheeler	20	Central & western Australia	Nornicotine & nicotine	
<i>N. ingulba</i> Black	20	Western Australia	Nicotine & nornicotine	Chewed as a narcotic ; said to assist during long dry marches, by causing salivation
<i>N. stenocarpa</i> Wheeler	..	Western Australia		
<i>N. occidentalis</i> Wheeler	21	South & western Australia		
<i>N. rotundifolia</i> Lindl.	22	Western & central Australia	Anabasine, nornicotine & nicotine	
<i>N. debneyi</i> Domin	24	Eastern coastal region of Australia & New Caledonia Is.	Anabasine & nicotine	nose, blue mould & black root rot
<i>N. benthamiana</i> Domin	19	Tropical regions of Australia	Nornicotine	Chewed as a narcotic by aborigines
<i>N. fragrans</i> Hook.	24	Melanesian & Polynesian Is.		

* Goodspeed, 335-489 ; Goodspeed & Thompson, *Bot. Rev.*, 1959, **25**, 392 ; Manske & Holmes, I, 250 ; Indian Tob. Monogr., 101-03, 125-26 ; Lucas, 51.

and curing tobacco. The forms under cultivation are generally known after the locality or area where they have been developed or cultivated : sometimes they bear names which indicate some prominent morphological characteristics. Detailed classification and description of cultivated forms are available for some commercial types of tobacco. Classification is, however, rather complicated since the same botanical type may be put to two or three commercial uses and

bear different trade names, while different botanical types may find the same commercial use and have a single trade name. The important commercial classes of tobacco in this country and the types under them are given in Table 2 (Gopinath & Hrishi, *Indian Tob.*, 1955, **5**, 187 ; Patel *et al.*, *ibid.*, 1959, **9**, 39, 101).

Improvement of tobacco in this country has been effected mainly by the introduction of new types from abroad and by selection from bulk crop to breed

pure lines. The breeding problems common to all tobaccos grown in the country relate to improvement of yield without impairing quality, good response to manuring and topping, and development of resistance to diseases and pests. In addition, there are problems of improvement specific to each type of tobacco. The crop presents, however, special difficulties in breeding for improvement; the value of the produce depends almost entirely on leaf quality as determined by chemical constituents and quality characters are neither clearly visible nor directly measurable in the field (Indian Tob. Monogr., 112, 114).

Self-pollination is the rule both in *N. rustica* and *N. tabacum*, but a certain amount of cross-pollination also takes place under natural conditions through the activity of the large number of insects which are attracted to the flowers by their bright colour and

abundant nectar. These two species have also been crossed with each other; the results are less successful when *N. rustica* is the female parent. The inter-specific cross is of interest as each species has some useful characters to supplement those of the other. The F₁ generation is highly sterile but by doubling the chromosome number allotetraploids with a high degree of fertility have been obtained (Howard *et al.*, Mem. Dep. Agric. India, Bot., 1910, 3, 307; Hunter & Leake, 224; Indian Tob. Monogr., 84).

Many types of tobacco grown in U.S.A. and other countries have been tested for resistance to diseases. From an extensive collection of material made in 1934-35 from Central and South America, types resistant to bacterial wilt and black root rot have been selected and utilized commercially. Recourse has also been taken to interspecific hybridization with other

TABLE 2—COMMERCIAL CLASSES OF TOBACCO AND IMPORTANT TYPES UNDER THEM CULTIVATED IN INDIA*

Commercial classes	Some important cultivated types	Principal areas where cultivated
CIGARETTE TOBACCO		
<i>N. tabacum</i>		
Virginia & other exotic types	Harrison Special, Chatham, White Burley & Delcrest	Andhra Pradesh & Mysore
Natu or Desi types	Thokkaku, Desa Vali & Dakshinarthi	Andhra Pradesh
BIDI TOBACCO		
<i>N. tabacum</i>	Keliu, Piliu, Gandiu, Saijpuri, Movadiu, Shengiu, Sokhadiu, Kalipat, Mirji, Nipani, Sangli, Surti & Jawari	Gujarat, Maharashtra & Mysore
<i>N. rustica</i>	Pandharpuri & Calcutta	Mysore, Maharashtra & Gujarat
CIGAR & CHEROOT TOBACCO		
<i>N. tabacum</i>	Chebrolu, Lanka, Natu, Vellaivazhai, Karingkappal, Karuvazhai, Oosikappal & Jati Bhengi; Dixie Shade (cigar wrapper only)	Andhra Pradesh, Madras & West Bengal
HOOKAH TOBACCO		
<i>N. tabacum</i>	Chama, Bhengi, Bori, Noki, Kakkar, Ghora & Gidri	Assam, West Bengal, Bihar, Uttar Pradesh & Punjab
<i>N. rustica</i>	Calcutta, Gobhi, Motihari & Vilayati	do.
CHEWING & SNUFF TOBACCO		
<i>N. tabacum</i>	Bonhrie, Kelia & Konnia of Uttar Pradesh, Bihar & Assam, Valmonnai, Meenampalayam & Sivapuri of Madras, Puchakkad of S. Kanara (Mysore State), Kali Chopdia & Judi of Gujarat are grown specially for chewing & a form known as Panan is grown for snuff in S. Kanara	Cultivated in almost every state of the Indian Union
<i>N. rustica</i>	No special form grown for snuff; forms grown for hookah are used for making snuff also	

* Indian Tob. Monogr., 4-7, 50-60, 297-362.

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Nicotiana spp. to evolve types which are resistant to diseases or which possess other desirable characters. *N. glauca*, *N. glutinosa*, *N. longiflora*, *N. debneyi*, *N. sylvestris*, *N. megalosiphon* and *N. plumbaginifolia* are some of the wild species employed in hybridization work (Indian Tob. Monogr., 101-03, 124-26; Lucas, 45-62; Garner, 456-58).

The degree of root development and resistance to water soaking are genetically controlled characters. Leaf characters like curing behaviour, flavour, aroma, body, texture, colour retention and burning quality are probably genetically controlled to a greater or lesser extent (Indian Tob. Monogr., 100).

Some of the standard varieties grown for commercial purposes are mixtures of strains differing widely in their nicotine content, but each breeding true with respect to the content of that alkaloid. Mutations in the form of abnormally low nicotine strains have been observed, though at rather rare intervals and only by the systematic examination of large populations. Studies on crosses involving bidi tobaccos with

very high nicotine content and flue cured tobaccos have shown that several genes are involved and high nicotine content is partially dominant (Garner, 458-59; Indian Tob. Monogr., 100, 127-28).

While there is considerable variation in *N. tabacum* and to some extent in *N. rustica* the occurrence of mutations under natural conditions is very rare in these two species. Only two mutants, *White Burley* and *Mammoth*, have been successfully exploited, the former now ranking second in importance among tobacco types cultivated in America; the latter is characterized by high leaf number (Garner, 452; Indian Tob. Monogr., 108).

Induction of mutations through irradiation has been attempted. Radiation techniques are likely to prove more successful in securing vigorous flue cured types than hybridization with local types in India, because of the bad curing behaviour of leaf in such hybrids (Indian Tob. Monogr., 108-12).

A list of improved strains obtained by selection and hybridization is given in Table 3.

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TABLE 3—IMPROVED STRAINS OF TOBACCO UNDER CULTIVATION*

Type of tobacco	Improved strains	Tract where cultivated	Improvement over existing strains
<i>N. tabacum</i>			
Flue cured cigarette	Harrison Special-9	Northern Circars	Yields more & is more uniform in growth & maturity
	Harrison Special	Northern Circars & Mysore	Similar to Harrison Special-9 in yield: standardized in habit & morphological characters
	Chatham	do.	Gives more bright grades under favourable cultural conditions than Harrison Special & stands late planting better
	Delcrest**	do.	Responds well to topping & yields 20-35% more bright leaf than Harrison Special or Chatham
Cigar wrapper	Rangpur Sumatra	Rangpur area of Bengal & Cooch Behar	Better adapted to local conditions than the original type introduced from Sumatra
	Dixie Shade**	do.	Superior in respect of both yield & quality to Rangpur Sumatra & other local types
Bidi	Kelu-49	Kaira dist.	Earlier in maturity by 10 days; takes less time for curing; spangles well: the final produce is parrot green & hence priced high
	Kelu-20	do.	Yields more than Kelu-49 but equal in quality

Contd

TABLE 3- *Contd.*

Type of tobacco	Improved strains	Tract where cultivated	Improvement over existing strains
Bidi-cum-chewing	Gandiu-6	Nadiad in Kaira dist.	A heavy yielder compared to Keliu-49 & is grown under irrigation, but quality is inferior
	Sorti-20	Kolhapur & Belgaum dist.	Yields more than the local strains
Bidi-cum-chewing	Saijpuriu-57	Kaira dist.	Yields more than the local strains
	Piliu-98	Petlad taluk of Kaira dist.	Better & more uniform growth & higher yield than the local strain
Cheroot	Ramol-43	do.	Earlier in maturity than Piliu 98
	D.R.I	Krishna, East & West Godavari dist.	Improved strain of local type (Lanka 27); yields more & responds well to manuring, irrigation & topping
Hookah Chewing	T.17**	Punjab	Yields 20-25% more than local strains
	N.P. 70	Bihar & U.P.	More uniform in growth & earlier in maturity than the local strains by 10-15 days
Hookah & Chewing	D.P. 401 (Bori Bharao 10)*	Bihar	Yields 30-35% more than the local strains & is superior in quality also
<i>N. rustica</i>			
Hookah & Chewing	N.P. 18	Punjab, U.P. & Bihar	Earlier in maturity by about 2 weeks & better in yield & quality
	T. 26, T. 218 & T. 238	Punjab	Superior in yield & nicotine content to local strains
Hookah & Chewing	C. 302**	Punjab	Late maturing type with suppressed inflorescence; produces less suckers & yields 20-35% more than T. 238; evolved by selection from a triple cross
	N.P.S. 219**	U.P., Punjab & Bihar	Large leaved strain, richer in nicotine content than locals & N.P. 18, & superior in yield also; evolved by hybridization of Indian strains with Canadian strains
	Hybrid T. 31 x T. 192**	Punjab	Gives 20-25% more yield than the existing improved strain T. 238 & is commercially grown

* Indian Tob. Monogr., 117-19.

** Information from the Director, Cent. Tob. Res. Inst., Rajahmundry.

TOBACCO CULTIVATION

Tobacco is reported to have been introduced into India by the Portuguese sometimes in the beginning of the seventeenth century and its cultivation seems to have been soon taken up in earnest. It was first grown for commercial purposes in Gujarat and Maharashtra, and cultivation spread to other parts of the country a little later. At present India occupies the third position among the tobacco producing countries in the world and ranks fifth in export trade (Table 4). Tobacco occupies the sixth place among the exportable commercial crops of India and from the point of revenue and trade it is of considerable importance to the economy of the country (Indian Tob. Monogr., 1; Brooks, J. E., 144, 209).

The important tobacco cultivating areas in India lie in Andhra Pradesh, Gujarat, Maharashtra, Mysore, Madras, Uttar Pradesh, Bihar and West Bengal, which together account for about 91.0% of the area and 93.0% of the production. The area and production of tobacco in different States in India are given in Table 5. Table 6 gives the important districts growing tobacco in each State and their percentage share in the total area under tobacco within the State.

Climate--Tobacco thrives well under tropical, subtropical and temperate climates. It requires 100-120 frost-free days with an average temperature of 27° to mature. In India, it is grown under a wide range of conditions from the coastal areas up to an altitude

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TABLE 4—AREA AND PRODUCTION OF TOBACCO IN SOME IMPORTANT TOBACCO PRODUCING COUNTRIES OF THE WORLD*

	Area (thousand hectares)					Production (thousand tonnes)				
	1958	1959	1960	1961	1962	1958	1959	1960	1961	1962
China (Mainland)	765	775	795	798	n.a.	768	794	823	832	n.a.
United States	436	466	462	475	497	788	815	882	935	1,026
India	353	363	370	400	415	231	265	287	312	344
Brazil	181	158	174	183	200	140	126	147	153	124
Indonesia	166	183	174	184	171	67	75	74	85	73
Turkey	160	168	188	141	158	115	128	135	100	98
Rhodesia & Nyasaland	153	159	136	134	145	88	105	117	119	123
Greece	113	102	92	102	130	84	80	65	75	92
Philippines	85	91	96	91	100	50	52	64	60	66
Pakistan	81	81	82	80	85	99	102	87	86	92
Canada	54	53	55	56	53	89	77	97	95	88
Estimated world total (inclusive of estimates for countries not listed here)	3,713	3,752	3,737	3,763	3,875	3,746	3,837	3,927	3,963	4,145

* *Tob. Bull.*, 1962, 12(4), 4; 1963, 13(3), 88; n.a.—not available.

TABLE 5—AREA AND PRODUCTION OF TOBACCO IN INDIA

	Area (thousand acres)						Production (thousand tons)							
	1957- 58	1958- 59	1959- 60	1960- 61	1961- 62	1962- 63	1957- 58	1958- 59	1959- 60	1960- 61	1961- 62	1962- 63		
Andhra Pradesh	335	359	356	355	386	413	415	104	109	118	116	124	148	150
Gujarat	165	151	165	216	229	229	188	35	43	46	59	83	95	69
Mysore	105	102	93	97	94	94	91	20	24	23	24	23	23	22
Maharashtra	72	56	58	65	62	48	50	16	10	14	12	15	10	10
West Bengal	40	39	38	43	41	38	37	11	10	10	14	13	11	11
Uttar Pradesh	34	42	43	48	41	39	40	11	13	13	16	12	13	10
Bihar	35	40	45	39	43	42	36	9	14	15	12	15	10	11
Madras	25	36	41	48	49	47	47	14	20	23	28	29	28	27
Assam	24	25	24	24	24	26	24	7	7	7	7	7	8	7
Rajasthan	9	15	17	15	16	12	12	2	3	4	5	4	4	4
Orissa	11	10	10	10	10	18	18	3	3	3	3	3	5	5
Madhya Pradesh	8	11	12	10	10	9	9	2	2	3	2	2	2	2
Punjab	4	4	4	4	4	4	4	1	1	1	1	1	1	1
Himachal Pradesh	2	2	2	1	2	2	2	a	a	a	a	a	a	a
Tripura	2	2	2	2	2	3	3	a	a	a	a	a	a	a
Delhi	1	1	1	1	1	a	a	1	1	1	1	1	a	a
Kerala	1	1	2	2	2	2	2	1	1	1	1	1	1	1
Jammu & Kashmir	n.a.	n.a.	1	1	1	2	2	n.a.	n.a.	a	a	a	1	1
TOTAL	873	896	914	989	1,025	1,028	980	227	261	282	307	339	360	331
	(353)	(363)	(370)	(400)	(415)	(416)	(397)	(231)	(265)	(287)	(312)	(344)	(366)	(335)

Figures in brackets give total area in thousand hectares and total production in thousand tonnes; n.a.—not available; a—below 500.

TABLE 6—IMPORTANT TOBACCO GROWING DISTRICTS IN INDIA (1960-61)

State	Percentage share in total area under the crop in India %	Important districts	Area under tobacco (in acres) and percentage share in the total area under the crop in the State
Andhra Pradesh	36.7	Guntur W. Godavari Krishna E. Godavari Khammamet	204,100 (57.5%) 31,100 (8.7%) 25,500 (7.2%) 24,400 (6.9%) 16,700 (4.5%)
Gujarat	22.3	Kaira Baroda	156,091 (72.2%) 42,000 (19.9%)
Mysore	10.3	Belgaum Mysore Kolar	58,480 (63%) 18,121 (18.2%) 6,440 (6.5%)
Maharashtra	5.6	Kolhapur Sangli	33,900 (63%) 8,500 (15.8%)
Uttar Pradesh	5.0	Farrukhabad Etah	15,045 (31.3%) 4,679 (9.7%)
West Bengal	4.5	Cooch Behar Jalpaiguri	31,900 (73.8%) 6,600 (15.3%)
Madras	4.4	Coimbatore	27,800 (65.4%)
Bihar	4.0	Muzaffarpur Darbhanga Purnea	13,389 (34.5%) 10,511 (27.0%) 8,334 (21.5%)

of 900 m. Temperatures above 35° cause leaf burn, particularly during periods of drought, but several types are grown under irrigation in areas where maximum temperatures are considerably higher. In general, the crop is raised in S. India from October to March when the temperatures are moderate and in the eastern and western parts of the country from September to January; in the Punjab it is grown as an early summer crop (Indian Tob. Monogr., 30, 149).

Soil—Tobacco is sensitive to the physical and chemical properties of the soil. The best soils are those which are open, well drained and well aerated. Light soils, particularly those sparingly supplied with nutrients, tend to produce thin, yellow and light-bodied leaves which are relatively weak in aroma. An increase in the supply of nitrogen and mineral elements may change the colour of the leaf to brown shades and may modify its chemical composition, but the resulting colour is not necessarily dark and normally there is no thickening. Heavy soils, on the other hand, tend to produce thick, heavy, dark coloured, heavy bodied and more gummy leaves with pronounced aroma. The desirable soil pH is 5.0 to 6.0 though in many tobacco areas, the pH is 8.0 or even more (Garner, 88, 61; Indian Tob. Monogr., 22, 149).

Cigarette tobacco is grown in India as a dry crop on heavy black soils of Andhra Pradesh. The soils have high moisture retaining capacity. The yield is low in comparison with that recorded in U.S.A. or Southern Rhodesia and the quality of leaf is also inferior. Cultivation on the lighter soils of Mysore yields tobacco of better quality. Details relating to soils on which commercial types of tobacco are grown in India are given in Table 7 (Indian Tob. Monogr., 22-30, 149-50, 297; Bhat, *Indian Tob.*, 1957, 7, 15; Uppal, *ibid.*, 1957, 7, 60).

Propagation—Tobacco is propagated by seeds. The quality and uniformity of crop depends on the purity of seeds. The presence of biotypes and off types has a disturbing effect on agricultural operations, maturity, resistance of crop to pests and diseases, and on the curing behaviour of harvested leaf. Contamination of seeds may be brought about by accidental admixture with off type seeds or by natural cross-pollination in the field. All non-flue cured tobaccos are topped leaving only a few plants for seed. The inclusion of even a single off type plant among seed plants would result in a substantial amount of impurity in the next crop (Indian Tob. Monogr., 289).

The extent of natural cross-pollination in tobacco types varies between 4 and 20%. Whereas outcrossing

TABLE 7—SOIL TYPES OF TOBACCO GROWING AREAS IN INDIA*

Type of tobacco	Region of cultivation	Soils
Flue cured	Andhra Pradesh	Heavy black clays known as black cotton soils
Bidi	Mysore	Well drained alluvial sandy or sandy loam soils found in the high level deltaic islands of the Godavari river
	Charotar (North Gujarat)	Red sandy loam soils
Cigar filler & binder	Nipani (Mysore)	Alluvial sandy to sandy loam soils, having a low content of organic matter & nitrogen, & containing 6-13.5% of clay & 50-80% sand
	Madras	Silt loams with a good capacity for retention of moisture
Hookah	Northern India	Sandy to loamy, well drained & red to brown in colour; alkaline in reaction & containing free calcium carbonate
Chewing	Northern India	Grown on a wide variety of soils; sandy to loamy soils in Bengal, sandy to silt loam alluvial soils which are alkaline in reaction & deficient in available phosphorus & potassium in northern Bihar, saline alluvial soils in U.P., & sandy loam soils which are alkaline & well supplied with plant nutrients in Punjab
	Madras	On the same soils as in the case of hookah tobacco
		Light gravelly to sandy loam, well drained, varying from grey to red in colour; consist of coastal sand in some areas

* Indian Tob. Monogr., 22-30.

with other types is undesirable, any type is at its best when maintained at the level of hybridity due to natural cross-pollination that obtains in the crop. The production of excessively pure seed by continued selfing is not recommended as such high purity may entail loss by "genetic erosion" of certain invisible quality characteristics and may also bring about a certain amount of deterioration and lack of adaptability. It is necessary to resort to progeny bulk breeding and maintenance after a relatively high

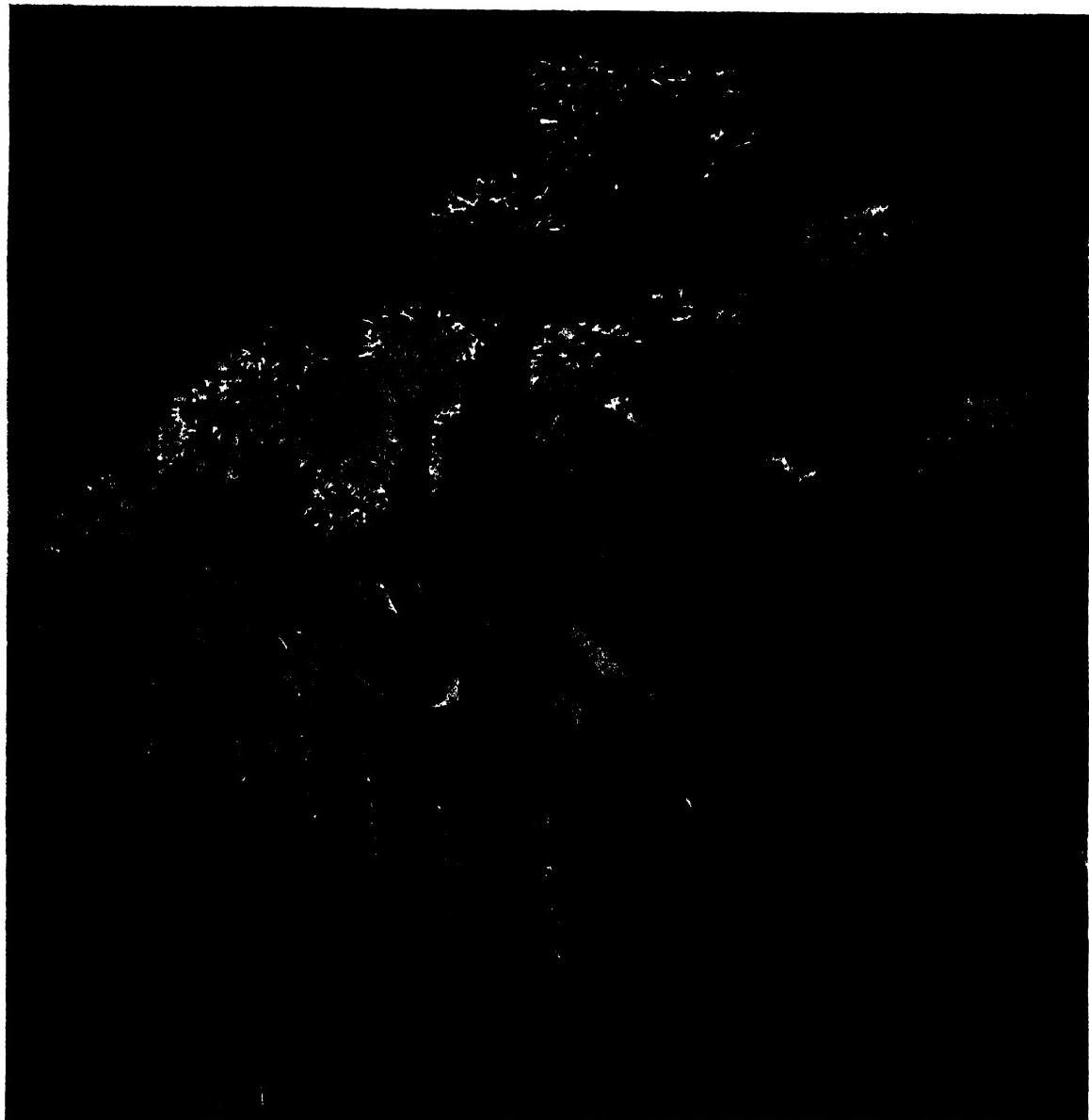
homozygosity and stability are reached for yield and quality factors (Indian Tob. Monogr., 291; Garner, 454-55).

For several years after the introduction of Virginia cigarette tobacco into India, there existed a belief that to produce crops of good quality, seed should be procured from its original home every other year. When the export of seed from U.S.A. was banned in 1936, it became necessary to produce seeds of Virginia tobacco within the country. Investigations showed that deterioration was mostly due to careless cultivation, harvesting and storing, when seeds of hybrids, off type plants and even indigenous types got mixed up. Procedures for raising seed plots and producing seeds have since been devised to eliminate possibilities of mechanical admixture and contamination through hybridization with other types. The Central Tobacco Research Institute and the Indian Leaf Tobacco Development Company are meeting the entire needs of pure Virginia tobacco seed in this country (Pal & Rao, *Indian Fmg*, 1944, 5, 516; Kadam et al., *Indian Tob.*, 1952, 2, 81; Krishnamurty, ibid., 1958, 8, 37; 1957, 7, 27).

After harvesting, the seed is winnowed in a processing chamber to remove light, immature or shrunken seeds, chaff and other foreign matter and then washed in water to separate floating debris; seeds which are light also float to the surface, but such seeds may be equal in all respects or even slightly better than heavy seeds; in trials they have given more total seedlings and larger number of transplants than heavy seeds. The seeds are usually treated with 0.1% silver nitrate solution in water for about 10 minutes; they are dried in shade and then in the sun for a few hours, packed in alka-thene bags and stored in a cool dry place (Indian Tob. Monogr., 295).

Tobacco seeds are reported to retain their viability for 20 years or more when stored in dry condition at ordinary temperature. Trials in India, however, have shown that they retain viability satisfactorily only up to about three years; there is an appreciable reduction in viability in the fourth year, followed by an almost total loss by the fifth year (Patil, *Indian Tob.*, 1955, 5, 23).

Seeds of good quality give about 90% germination; the optimum temperature for germination is 24-30°. The germinating capacity of seeds from varieties recently introduced into India is generally lower than those of varieties acclimatized to Indian conditions for a long time. The latter give high germination at



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temperatures even higher than those reported as optimum in foreign countries (Garner, 310; Pal & Gopalachari, *J. Indian bot. Soc.*, 1957, 36, 262).

Nursery practices—Tobacco seedlings are raised in nursery beds, 1.2–1.4 m. wide and of any convenient length. They may be flat or raised 5.0–7.5 cm. above ground level to prevent waterlogging. The soil of the seed bed is partially sterilized to destroy weed seeds, soil borne diseases and insect pests. Under Indian conditions, rabbing or burning trash on the surface and application of fungicidal sprays are the only practicable methods. Rabbing is reported to improve the soil structure and fertility and is done before the application of manures (Garner, 116–20; Indian Tob. Monogr., 161–62).

Tobacco seed contains very little reserve food and seed beds have to be well manured. Farmyard manure is applied at the rate of 25–125 tonnes/ha.; groundnut or composted castor cake may also be applied at the rate of 45–130 kg. N/ha. The seeds are small (12,500–14,500 seeds/g.); they are mixed with fertilizer, soil or sand to secure a desirable volume for handling; or the seeds may be stirred in water and applied to the bed through a sprinkling

can. They are sometimes rubbed with kerosene oil to prevent them from being carried away by ants (Indian Tob. Monogr., 164; Garner, 125; Yegna Narayan Aiyer, 422, 430).

Depending on the growing season and type of tobacco, the sowing time in most of the regions extends from the first week of July to the third week of September; in Punjab, sowing is done in the months of November and December, while in Uttar Pradesh it is done from the middle of February to the middle of March. Seeds previously exposed to a low temperature (10–12°) for 10 days may be used for sowing if the soil temperature is high (31–41°) during the sowing season. Pretreated seeds should be sown within 2–3 hours after they are taken out of the refrigerator. Use of pretreated seeds is said to result in earlier and more uniform germination and larger number of transplantable seedlings. About 2.75–3.5 kg. of seed/ha. of nursery is the optimum rate of sowing; in the case of *N. rustica* whose seeds are larger the rate is 4.5–6.7 kg. About 25–40 sq.m. of nursery will normally give seedlings sufficient to plant 0.5–1.0 hectare of land. After sowing, the surface of the bed is pressed down lightly with hand

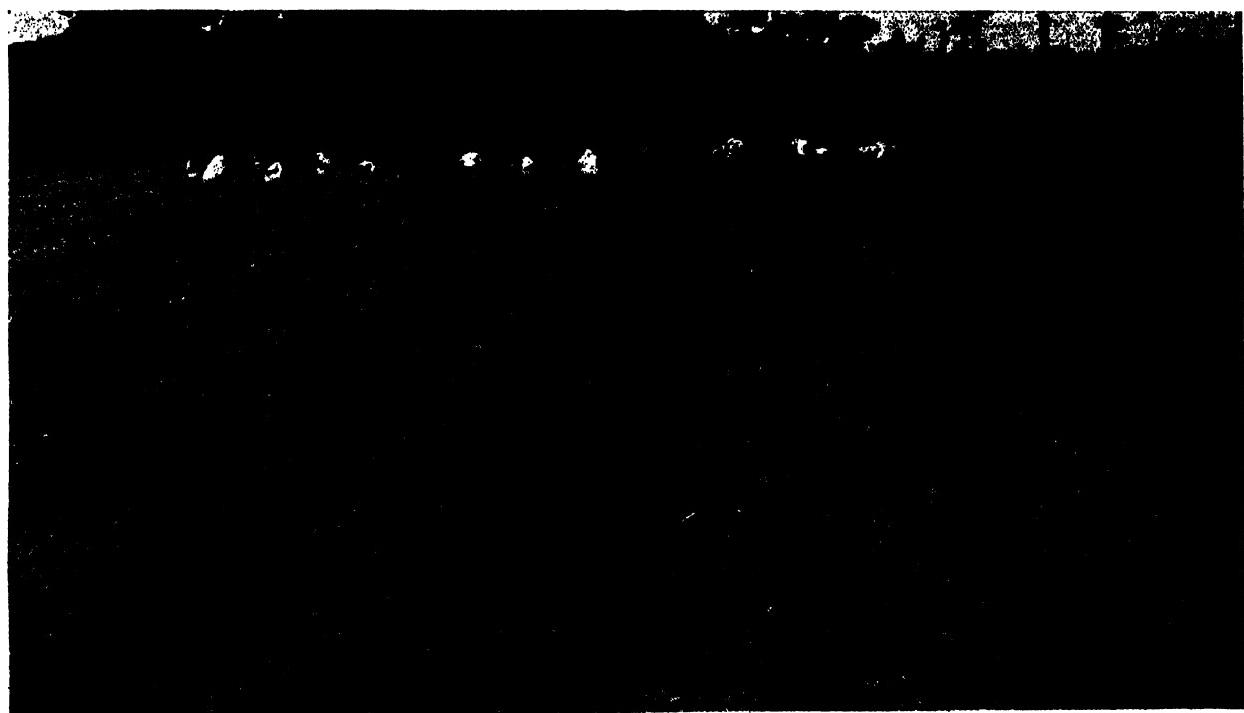


FIG. 13—NICOTIANA TABACUM—SEEDLING NURSERY

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or a wooden roller and covered over with a light thatch of straw or twigs. The surface of the seed bed is kept moist by frequent light watering. As the seedlings get larger the frequency of watering is decreased. Liberal watering may cause yellowing of plants and may also leach out the nutrients from the soil ; in such cases an application of 1% sodium nitrate solution (2.7 kg./100 sq.m.) gives good results. Seedlings are ready for transplantation in 7-9 weeks after sowing in the case of *N. tabacum* and in 5-6 weeks in the case of *N. rustica*. In Punjab, where the nursery is raised in the cold season, the seedlings are transplanted after 9-12 weeks. Table 8 gives details

regarding the period of sowing and transplantation for the various types of tobacco in the different tobacco growing areas of the country (Indian Tob. Monogr., 164-66 ; Pal *et al.*, Indian Tob., 1959, 9, 65 ; Garner, 125-28).

Preparation of land—Thorough cultivation of soil is a matter of prime importance for tobacco since the mechanical properties of the soil have a pronounced effect on the characteristics of leaf. The field is ploughed 4-6 times and farmyard manure is applied at the rate of 7.5-12.5 tonnes/ha. for the flue cured types in Andhra Pradesh and Mysore and 25-30 tonnes for the other types of tobacco in the

TABLE 8—TIME OF SOWING, TRANSPLANTATION AND HARVESTING OF TOBACCO

Type	Area	Sowing period	Transplantation period	Harvesting period	Method of harvesting
Cigarette: flue cured Virginia	Andhra Pradesh	August	October to mid-December	January to March	Leafwise
do.	Mysore	February to April	April to June	June to October	do.
Cigarette: sun cured Natu	Andhra Pradesh	Early September	Late October to early November	March to April	All the leaves at the same time
Bidi	Gujarat, Maharashtra & Mysore	First week of July	Middle of August to middle of September	December to January	Leafwise or the whole plant, as the case may be
Cigar	Madras	August	Mid-September to October	Mid-December to January	Whole plant
Cigar wrapper	West Bengal	August	Early October	December to January	Leafwise
Cheroot & Chutta; Lanka tobacco	Andhra Pradesh	August to September	Late October to early December	January to March	Whole plant
Hookah & Chewing	Punjab	November to December	March	<i>Rustica</i> types from mid-May to mid-June; <i>Tabacum</i> types a month later	do.
do.	Bihar	<i>Rustica</i> types: late September to mid-October <i>Tabacum</i> types: late July to mid-August	Late October to November Late September to mid-October	February to March January to February	do. do.
do.	Uttar Pradesh	August to September for winter crop February to March for summer crop	October to November April	April June	do. do.
do.	West Bengal	<i>Rustica</i> types: late September to mid-October <i>Tabacum</i> types: late August to early September	Late October to mid-November Mid-October to early November	February onwards do.	Leafwise do.
Chewing	Madras	Late August to December	Late October to November-December	110 to 120 days after transplanting	Whole plant
do.	Kerala	August	September to October	do.	do.

various cultivating regions. In Madras under intensive cultivation of chewing tobacco up to 125 tonnes of farmyard manure per hectare are applied, while in parts of Uttar Pradesh where the crop is irrigated with brackish water from wells no manure is applied. Oilseed cake is often used to supplement farmyard manure in areas growing bidi, cigar and cheroot types to supply 60-175 kg. N/ha. (Indian Tob. Monogr., 177, 181, 187, 299, 313, 326, 346, 356).

Fertilizer requirements—While nitrogen is necessary for the development of leaf, an excess of it leads to deterioration in aroma and taste. Phosphate and potash together exert a favourable influence on the formation of leaf sugars. The application of phosphate improves the size of leaf and promotes uniform ripening. Potash is, however, the most important fertilizer element; it exerts an effect on quality and yield of tobacco, increases resistance to fungal diseases, and improves the colour, combustibility and aroma of leaf.

The requirements of fertilizers vary from region to region depending upon the nutrient status of the soil, type of tobacco grown and availability of irrigation facilities. In general, Virginia tobacco thrives well with application per hectare of 17-22 kg. nitrogen, 67-90 kg. phosphoric acid and 67-90 kg. potash; for other types of tobacco, fertilizers are applied to supply 45-57 kg. nitrogen, 35-45 kg. phosphoric acid and 35-45 kg. potash per hectare. Ammonium chloride and muriate of potash should be avoided as they have an undesirable effect on the burning quality of tobacco. The full dose of fertilizers should be applied at the time of transplanting [Indian Tob. Monogr., 139-45; Garner, 330-43; Jakate, *Fertil. News*, 1962, 7(11), 15].

Transplanting—Transplanting is done by hand for all tobaccos in India. The field is marked and plants set in flat beds or on ridges. Planting is generally done on a rainy day or after irrigating the field. In Uttar Pradesh and Punjab, planting is done in dry soil and the field is immediately irrigated. Ridging is reported to be desirable under irrigated conditions as it economizes irrigation water and maintains better soil aeration; planting in flat beds is better for dry conditions and in sandy areas.

The spacing between plants varies according to the type of tobacco grown and the soil. The number of plants per hectare varies from 12,500 for cigarette tobacco and broad leaf chewing tobacco, to 100,000 for hookah tobacco in Punjab. Trials with chewing, cigar and hookah tobaccos have shown that wide

spacing gives significant increase in leaf size and thickness, as well as green weight and cured leaf yield. Close spacing gives increased yield but the increase is not proportional to the increase in plant population. Close spacing is generally desirable for late planting. The normal spacing varies from 75 to 100 cm. either way for cigarette tobacco in Andhra Pradesh and Mysore, bidi tobacco in Nipani and Charotar and cigar and chewing tobaccos in Madras. In Punjab, it varies from 23 cm. x 37 cm. to 15 cm. x 30 cm. for hookah tobaccos. In West Bengal and Uttar Pradesh, a medium spacing of 50 cm. x 60 cm. is given for Rustica types.

The crop is generally intercultured 3-4 times at intervals of about a fortnight, but in West Bengal where the subsoil water level during the tobacco growing season is high, this operation is carried out at intervals of 3-4 days for the first month and later at weekly intervals so that excess of soil moisture is removed and the soil aerated. All interculturing operations are completed within 2-2½ months after transplanting as later cultivation is likely to damage the roots and leaves of grown up plants (Indian Tob. Monogr., 169-73).

Topping and desuckering—The plants are topped when they are 90-100 cm. high or 5-6 weeks old. Following topping, axillary buds grow out from leaf axils as vigorous shoots or suckers and these are removed regularly as they appear or their growth is suppressed by applying coconut oil at the top five or six leaf axils soon after topping. Application of naphthalene acetic acid at 2% concentration is said to suppress suckers in cigar and chewing tobaccos. As a consequence of topping there is diversion of nutrients from flower heads to leaves. The time and height of topping have important effects on the development of leaves. In recent years there is a tendency in the United States towards later and higher topping usually combined with heavier fertilization, the principal purpose being to secure an increased yield of the desired grades of leaf from a restricted area. In India, cigarette tobacco is not usually topped, but observations indicate that the crop benefits by high topping of flower head. Topping is done in the case of all other types of tobacco and the number of leaves retained—excluding 3-4 sand leaves at the bottom which are also removed—varies from type to type; it is 5-7 for Rustica types of hookah tobacco in West Bengal, 6-10 for chewing tobacco in Madras, 11-12 for bidi types and 12-14 for broad leaf cigar and some hookah types (Indian



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FIG. 14—CROP OF JATI TOBACCO AFTER TOPPING

Tob. Monogr., 173-76; Krishnamurthy, Indian Tob., 1959, 9, 244; Garner, 140-46).

Rotation—In order to furnish protection against soil erosion, disease or insect infestation and depletion of soil fertility, tobacco is grown in rotation with other crops. In U.S.A. legume rotation is not considered desirable for cigarette tobacco since the extra nitrogen stored up in the soil adversely affects the quality of the leaf. Crops like maize, cotton, tomato and sweet potato are said to favour development of root knot on light soils while peanut, chillies, sweet potato and tomato increase wilt hazard in some areas. In some soils continuous cropping of tobacco is said to give better results than rotation, provided due attention is given to manuring. Available evidence on crop rotation in India supports the conclusions reached in U.S.A. In most areas tobacco is a monoculture crop and no deleterious effect has been noticed in yield or quality over a number of years. In cigarette tobacco areas, however, continuous cropping is reported to affect leaf quality. Jowar, rice, ragi or ragi-pulse mixture, sugarcane, cotton, chillies, horsegram, niger, gingelli, turmeric, onions and garlic are some of the crops grown in rotation with tobacco in this country (Garner, 61-62, 92-100; Indian Tob. Monogr., 150-52; Yegna Narayan Aiyer, 420; Mudaliar, 490; Lucas, 28-31).

DISEASES AND PESTS

Diseases—Damping off of seedlings in the nursery is caused by *Pythium aphanidermatum* (Edson) Fitzp. The disease is favoured by rainy weather and high humidity as well as by overcrowding of seedlings. Spraying with Bordeaux mixture or Perenox at intervals of 3-7 days provides control. Copper fungicides like Fytolan, Coppersan, Shell Copper and Micop have also been found effective (Indian Tob. Monogr., 235).

Black shank, caused by *Phytophthora colocasiae* Racib. emend Thomas & Ramakr. affects tobacco in the nursery as well as in the field; the disease occurs sporadically and causes damage to irrigated crops and to crops grown on light soils. The infection is spread by water, soil and wind-blown dust. Affected plants show blackening of roots and stalk and wilting of leaves; 2 to 3 weekly sprayings with Bordeaux mixture or Perenox in the nursery and drenching the soil near the base of the plant in the field with Bordeaux mixture keep the disease in check. Diseased stalks and roots should be destroyed by burning (Indian Tob. Monogr., 236-37; Butler, Bisby & Vasudeva, 20; Lucas, 115-39).

A root rot complex known as *chitri* disease affecting bidi tobacco is fairly widespread in Gujarat. Nematodes as well as species of *Fusarium* and *Rhizoctonia* are associated with the rot. In affected young plants, all leaves wilt simultaneously while in older ones wilting is gradual from the bottom leaf upwards. The roots show brown discolouration which may extend to the lower portion of the stem. The disease is soil-borne; diseased stalks and roots should be removed and cultivation of tobacco on the same field year after year should be avoided (Indian Tob. Monogr., 238).

Anthracnose, caused by *Colletotrichum tabacum* Bonning, is reported to be serious in the nursery, but rarely observed in the field. The infection starts from the lower leaves and appears as circular lesions formed by the coalescence of a number of water soaked spots; sometimes the entire seedling is affected. The pathogen persists in the soil on plant debris. The latter should be removed and burnt. Spraying with Perenox, Bordeaux mixture, Dithane or Fermate at intervals of a week or less during wet weather affords protection (Indian Tob. Monogr., 239).

Frog-eye leaf spot is caused by *Cercospora nicotianae* Ellis & Everh. The parasite normally attacks only physiologically declining tissue in the plant both in the nursery and in the field; it is not

a serious disease in this country. Spots with ashy grey centres of dead tissue surrounded by a yellow ring which turns brown to black later, are found on the lower leaves. In cases where the infection has taken place just before harvest, the spot may develop in the barn while curing. Rainy weather during the cropping season increases the incidence of the disease. Spraying with Bordeaux mixture gives control (Indian Tob. Monogr., 239; Lucas, 236-41).

Brown spot, caused by *Alternaria longipes* (Ellis & Everh.) Mason, is prevalent in the field, particularly in the topped crop. As the organism is said to over-summer in the soil on leaves and stalks, the primary infection can be checked by removing the diseased refuse and avoiding continuous culture of tobacco in the same field (Indian Tob. Monogr., 240; Lucas, 228-35).

Powdery mildew (ash disease) is fairly widespread on all types of tobacco but is severe in flue cured tobacco in the low-lying areas of Andhra Pradesh and in Mysore. The disease is caused by *Erysiphe cichoracearum* var. *nicotianae* Comes. Maturing plants are attacked; the infection starts from the lower leaves in the form of greyish white spots which may spread and cover the entire leaf surface. Affected leaves get scorched on curing, while incipient infections appear as blemishes. Overfertilizing and overcrowding of plants in the field should be avoided. Pruning of lower leaves also helps to reduce the incidence. Application of sulphur to the soil at 45 kg./ha. provides effective control (Indian Tob. Monogr., 242).

Angular leaf spot, caused by *Pseudomonas angulata* (Fromme & Murray) Holland, is prevalent in tracts where tobacco is grown as a monsoon crop. The disease appears in seedlings in the form of black or dark brown spots which frequently coalesce; leaves of infected plants in the field show bigger spots. The causative bacterium is found on the roots of pasture, weed and crop plants, as well as on rootlets of infected tobacco plants in the nursery and field. Seed from diseased plants may be contaminated and remain so for as long as two years. Seed treatment with silver nitrate (1:1000) for 10-15 minutes gives some protection. The site of the nursery should be changed every year and tobacco refuse from previous crops should be removed. Spraying with Bordeaux mixture affords protection; streptomycin applied as a spray gives excellent results (Indian Tob. Monogr., 241; Garner, 258; Lucas, 328-50).

Tobacco is subject to mosaic and leaf curl, both

caused by viruses. Mosaic is caused by *Nicotiana virus 1* (*Marmor tabaci* Holmes). Early infection lowers yield and quality, while late infection causes little damage. The virus remains viable in infected dry leaf as well as soil for many years, but is not carried through seed or transmitted by any insect vector. Strict sanitary measures in the nursery and in the field should be observed to avoid infection and all diseased plants should be destroyed. All the cultivated types of tobacco are susceptible. A wild species *N. glutinosa* which is fairly resistant is being tried for breeding resistant types (Indian Tob. Monogr., 243; Garner, 262; Lucas, 354-76).

Leaf curl, caused by *Nicotiana virus 10* (*Ruga tabaci* Holmes), is transmitted by the white fly, *Bemisia tabaci* Genn. Five types of leaf curl have been differentiated on the basis of symptoms. The incidence of the disease is reported to be greater in Gujarat and northern parts of India than elsewhere. Spraying the nursery with an insecticide at intervals of a week is recommended (Indian Tob. Monogr., 245; Lucas, 388-92).

Frenching is a non-parasitic and non-infectious disease observed sporadically in certain seasons in seed beds and more rarely in individual plants in the field. It may sometimes be confused with tobacco mosaic. In the most severe form, the plant never emerges from the rosette stage and rudimentary leaves consisting of hardly more than strings continue to form in large numbers. The causal agent is supposed to be a physiological soil factor; according to some, the diffusate from *Bacillus cereus* Frankland & Frankland acts as a soil toxin and is the primary cause of the disease. All species of *Nicotiana* except *N. acaulis* Specazzini and *N. thrysiflora* Bitter ex Goodspeed are susceptible to frenching. This disease can be prevented by soil sterilization with heat, formaldehyde or other chemicals. It is also advisable to avoid planting of frenched seedlings and grow tobacco in rotation with other crops (Garner, 266; Indian Tob. Monogr., 246; Lucas, 316-22; Wark, *J. Aust. Inst. agric. Sci.*, 1961, 27, 160).

Pests—The most serious pests of tobacco in the nursery are: leaf caterpillars, cut worms, stem borers and white flies. Caterpillars of *Prodenia litura* Fabricius, *Laphygma exigua* Hübner, *Plusia signata* Fabricius and *Agrotis ypsilon* Rott. attack seedlings during the night feeding on tender leaves and juicy stems. Eggs are laid on leaves and stem, while pupation takes place in the soil. The infestation may continue from the nursery to the field also. Cultural

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practices by way of ploughing, regular interculturing and stirring of soil below the plants help in the destruction of pupae. Spraying with DDT 50%, lead arsenate or Guesarol 550 is recommended for controlling caterpillars of the first 3 species; 5% Paris green or BHC poison bait is effective against the last. Dieldrin also gives good results against larvae of *Prodenia litura* (Indian Tob. Monogr., 252-56; Kadam, *Farm Bull. Indian Coun. agric. Res.*, No. 10, 1956, 57; Joshi & Kurup, *Indian Tob.*, 1960, 10, 165).

Stem borer, *Gnorimoschema heliopa* Lower, is a serious pest, particularly of flue cured and *Natu* tobacco in Andhra Pradesh and bidi tobacco in Bombay. The moth is active at night and lays eggs on the lower surface of leaves. The larva mines its way along the midrib and reaches the stem where it pupates. The growing point is destroyed and the plant throws out bushy and abnormal branches. Wilted leaves or swollen stem near the growing tip are indications of borer attack. Infested leaves should be removed and the swelling on the stem incised and the larva scooped out. Syringing of wettable BHC or DDT suspension with a hypodermic syringe into infected plants affords control. Spraying of plants in the nursery or field with pongam oil resin soap, lead calcium arsenate, DDT or BHC is recommended. Covering of seed beds with a thin cloth at night to prevent egg-laying by moths, dipping of seedlings in calcium arsenate solution before planting and destruction by burning of tobacco stubble left in the field after harvest, are among other preventive measures recommended (Indian Tob. Monogr., 256-58; Yegna Narayan Aiyer, 438).

Gryllotalpa africana Pallas, a mole cricket, causes damage by burrowing into the soil of the nursery and feeding on the underground parts of seedlings. Thorough cultivation of soil, elimination of excessive humus and improved drainage are beneficial. Use of poison bait made of flour and Paris green, application of Parathion with a sprinkling can or spraying with Aldrin, Dieldrin, Endrin, Folidol or DDT after sowing seeds are recommended as control measures (Indian Tob. Monogr., 260-61).

Beetles (*Bledius gracilicornis* Kraatz, *Oxytelus latiusculus* Kraatz, *Rhyssemus orientalis* Mulsant and *Onthophagus* sp.), maggots of the house fly (*Musca domestica* Linn.), and black crickets (*Tridactylus riparius* Saussure) are some of the other pests of tobacco nursery. They can be controlled by methods recommended against mole cricket (Indian Tob. Monogr., 261-62).

Ground beetles or cut beetles belonging to the species *Mesomorphius villiger* Blanchard, *Seleron latipes* Guerin and *Opatroides frater* Fairmaire gnaw or cut tender stems of transplanted seedlings. Dieldrin 50% applied through transplant water gives effective control. Chlordane, Aldrin and Endrin are also effective. A mixture of Gammexane and sand may be spread round the plants to repel the beetles (Indian Tob. Monogr., 262-64; Kadam, *Farm Bull. Indian Coun. agric. Res.*, No. 10, 1956, 58).

The aphid, *Myzus persicae* Sulzer, attacks leaves of growing plants; it is also known to transmit some virus diseases. During heavy infestation the under surface of leaves is densely covered with these insects and a sugary liquid exudes which favours the development of a black mould known as sooty mould. Spraying with tobacco decoction is an old and fairly satisfactory method of control. Preventive treatment with insecticides like Parathion is recommended; trials at Rajahmundry have shown that Basudine 20% or Endrin 19.5% combined with DDT 50% provides full control. Systemic insecticides have also been successfully tried against the aphids (Indian Tob. Monogr., 264-67).

Hairy caterpillars (*Amsacta* sp.) cause much damage to the young crop. Cleaning of hedges, bunds and weeds on which eggs are likely to be laid, hand picking the caterpillars when seen and provision of light traps to attract the moths after the first showers in June are some of the preventive measures. Use of Paris green or 5% BHC or DDT poison bait and dusting the infested field with sodium fluosilicate or spraying with Pyrethrum are also recommended (Indian Tob. Monogr., 267).

Caterpillars of *Heliothis armigera* Hübner feed on tender shoots and inflorescence of tobacco plants, bore into the developing capsule and feed on immature seeds. They can be controlled by hand picking and the pupae are destroyed by thorough ploughing of the field after harvest. Application of DDT as spray or dust also gives control (Indian Tob. Monogr., 268-69).

The larva of the cigarette beetle, *Lasioderma serricorne* Fabricius, is a destructive pest of stored tobacco of all types. Fumigation has been found to be effective. Redrying at 160-170°F. brings about complete mortality of adults and almost complete mortality of eggs, larvae and pupae (Indian Tob. Monogr., 269-71).

Root-knot, caused by two species of nematodes, *Meloidogyne incognita* (Kofoid & White) and

M. arenaria (Neal), is restricted to light sandy soils in Gujarat and Mysore and some nurseries in sandy areas in Andhra Pradesh. The roots of infected plants show galls or knots of round to irregular shape. Heavily infested plants wilt, become dwarfed and yellowed, and eventually die out. Nurseries should not be raised in soils where root-knot has been observed in previous years and infected seedlings should be eliminated from the nursery. The crop may be rotated with a non-susceptible crop to reduce the nematode population in the soil. Application of fumigant like DD (dichloropropene-dichloropropene), Dow W-40 (ethylene dibromide) or methyl bromide to the soil affords effective control. Burning trash over nursery bed sites also eliminates nematodes in the top 8-10 cm. of soil (Indian Tob. Monogr., 248; Lucas, 63-91).

Orobanche (Broom Rape; HINDI—*Tokra*; MAR.—*Bambaku*; GUJ.—*Vakumba*; TEL.—*Bodu, malle*; TAM.—*Pokayilaikalan*) is a phanerogamous parasite on tobacco which occurs sporadically in all tobacco tracts in India. Two species of the parasite are known, namely *Orobanche cernua* Loefl. var. *desertorum* Beck syn. *O. nicotianae* Wight and *O. aegyptiaca* Pers. syn. *O. indica* Buch.-Ham. ex Roxb., the former being the more serious. *Orobanche* shoots develop from a swollen base which is connected to the roots of the host by a fragile attachment. The development of the parasite is favoured by irrigation; shoots emerge out of the soil 5-6 weeks after planting tobacco and grow up to a size of 15-45 cm. Parasitized plants are reduced in size and their leaves may turn yellow and wilt. The parasite bears flowers and seeds, the latter being extremely small (184,000 seeds per grain in *Orobanche* as compared to 10,000 in tobacco) and viable for many years. The only effective control is the continuous removal over a number of years of parasitic shoots by hand before they set seed and their destruction by burning. Spraying with Crag herbicide I has been found to reduce the incidence of *Orobanche* (Indian Tob. Monogr., 246-48).

HARVESTING AND YIELD

The stage of maturity at which the crop is best harvested depends chiefly on the type of tobacco. In the case of flue cured cigarette tobacco, only leaves which show a slight yellowish tinge are harvested. In bidi types, the crop is considered ready for harvest when the majority of leaves have a spangled or mottled appearance. The cigar and cheroot crop is fit for harvest when the leaves pucker, become

yellowish green in colour and brittle; in hookah types, thick broad yellowish brown flecks appear at this stage on the leaves (Indian Tob. Monogr., 189-92).

Cigarette tobacco is harvested by priming; only those leaves that are ripe for harvest are removed from the plant at a time and the entire harvest is completed in 5 to 6 primings at intervals of about a week. This method is followed in the case of cigar wrapper tobacco also and in some areas for bidi and hookah tobaccos also. In all other cases, harvesting is done by cutting the plant close to the ground and allowing it to lie in the field overnight for wilting. Details regarding the time and method of harvesting for the different commercial types in the various areas are given in Table 8 (Indian Tob. Monogr., 190-92).

The yield of cured leaf varies with the region and the type cultivated. The average yield per hectare of flue cured tobacco in Andhra Pradesh is about 790 kg.



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FIG. 15—NICOTIANA TABACUM—HARVESTING

TABLE 9—YIELD OF TOBACCO IN THE IMPORTANT TOBACCO CULTIVATING STATES IN INDIA
(kg./ha.)

	1959-60	1960-61	1961-62	1962-63
Andhra Pradesh	786	732	722	744
Bihar	838	689	729	800
Gujarat	—	612	812	929
Maharashtra	677*	414	542	494
Madras	1,416	1,307	1,326	1,334
Mysore	610	554	531	542
Uttar Pradesh	759	747	672	728
West Bengal	726	729	710	648
All India (average)	756	695	738	761

* Average yield for undivided Bombay.

TABLE 10—YIELD OF TOBACCO IN SOME IMPORTANT COUNTRIES*
(kg./ha.)

	1959-60	1960-61	1961-62	1962-63
Brazil	790	760	740	800
Bulgaria	830	710	580	890
Canada	1,490	1,770	1,700	1,740
Greece	780	670	720	730
India	730	770	780	830
Indonesia	420	420	400	390
Japan	2,080	2,050	2,210	2,170
Pakistan	1,840	1,080	1,070	1,150
Philippines	570	660	690	700
Southern Rhodesia	1,290	1,190	1,180	940
Turkey	730	720	730	1,000
U.S.A.	1,750	1,910	1,970	2,120
U.S.S.R.	1,240	1,190	920	990

* *Prod. Yearb. FAO*, 1961, 15, 135; 1963, 17, 137.

while in Mysore it is somewhat higher, about 1,125 kg. A well-managed crop of broad leaf cigar type in Madras may yield 1,335–1,680 kg./ha.; narrow leaf types yield slightly less. The yield of *Natu* tobacco is about 1,680 kg./ha. in the Guntur area, while in West Godavari the yield ranges from 1,790 to 2,250 kg. Among hookah tobaccos the yield of *Tabacum* types varies from 890 to 1,110 kg. of leaf and of *Rustica* types from 1,335 to 1,610 kg./ha., inclusive of stems. The average yield per hectare for all types of tobacco in the different States varies from 390 to 1,465 kg. (Table 9). The yield of tobacco, however, is low in India as compared to some other important producing countries like U.S.A., Canada, Japan and U.S.S.R. (Table 10) (Indian Tob. Monogr., 306, 329, 339, 340, 352; Kadam, *Farm Bull. Indian Coun. agric. Res.*, No. 10, 1956, 32).

CURING

The harvested leaves are cured before marketing. Curing consists essentially in drying the leaves gradually under conditions which permit certain changes in chemical composition essential for development of the desired quality. Four methods of curing are recognized, namely (i) flue curing, (ii) sun curing, (iii) air curing, and (iv) fire curing (Garner, 399; Indian Tob. Monogr., 277, 358).

Flue curing--A large part of the tobacco used in cigarette manufacture is flue cured in barns specially designed for the purpose. Two sizes of barns, approx. 5 m. × 5 m. × 5 m. (high) and 5 m. × 7.5 m. × 5 m. (high) are commonly used in India; the former is equipped with one furnace and the latter with two. Trials have shown that a barn 5 m. × 6 m. in cross-section, with one furnace and a suitable system of flue pipes is satisfactory under Indian conditions. The furnace (1.2 m. × 0.4 m.) is fired by coal or wood. A system of flue pipes starts from the furnace and is distributed along the sides of the barn and led out through the wall as a chimney. The entrance to the barn is situated just opposite the furnace. Humidity in the barn is controlled by suitable ventilation. A number of windows are provided close to the floor for ingress of air and a big opening in the roof for the exit of air. An improved arrangement for ventilation consists in providing numerous slits in the walls at floor level all round at intervals of 10 cm., the opening being controlled by sliding planks operated from outside; two ventilators, 1.8 m. × 25 cm., are provided at the top on each side of the ridge of the roof and are controlled by pulley arrangements. The



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FIG. 16—TOBACCO CURING BARNS

barn is furnished with a system of tiers in five levels on which bamboo sticks (c. 1.5 m. long) strung with tobacco leaves are loaded. A wet and dry bulb thermometer which is suspended in the centre of the barn can be pulled towards a window to record at regular intervals the temperature and humidity obtaining in the barn (Indian Tob. Monogr., 283-88; Garner, 162-67).

The leaves are harvested in the early morning and immediately taken to a cool thatched shed near the barn, where they are strung on to bamboo sticks each of which takes about a hundred leaves. A barn, 5 m. x 5 m. in size, can take about 650-750 sticks with a total of about 1,500-2,000 kg. of green leaf. While stringing, it is desirable to separate the leaves according to maturity into yellowish, light green and green grades so that by loading the comparatively immature grades in the upper tiers of the barn a more uniform curing is ensured. The operations of stringing and loading into barns should be done as soon as possible on the same day (Indian Tob. Monogr., 304; Garner, 189).

Flue curing consists essentially in yellowing the leaf at moderate temperature and high relative humidity and then drying the leaf web and stem by increasing the temperature and lowering the humidity in such a way that there is no discolouration. The procedure to be followed and time intervals given for the three principal phases of curing namely, yellowing, fixing the yellow colour and drying, vary with the maturity of the raw leaf and the prevailing weather conditions. Yellowing takes 24-40 hours during which period the temperature is kept below 95°F. and relative humidity maintained at 80-90%: little or no ventilation is required. As yellowing progresses, the temperature is raised gradually (c. 1-2°/hr.) till it reaches 105°F. Some ventilation may be provided at this stage. The yellowing phase continues until the majority of leaves in the barn have attained a golden yellow colour and the relative humidity reaches 75%. The colour is then fixed by raising the temperature to c. 125°F. over a period of 7-10 hours and the ventilators are opened. The temperature is now raised rapidly to about 150°F. and maintained till the lamina is dry. After about 50 hours, the ventilators are closed and the temperature is further raised to 155-160°F. to dry the mid-rib and the leaf becomes completely dry in 100-125 hours of curing. In a modified method of curing, a certain amount of drying is effected during the yellowing and the time taken to dry the leaves in the upper tiers



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FIG. 17—STRINGING TOBACCO LEAVES FOR CURING

is minimized by reducing the ventilation and so raising the temperature. Improvements in the construction of the barn and schedule of curing are said to have resulted in economy of curing time and fuel and to have given a higher percentage of bright grades of cured leaf. A higher percentage of bright grades can be obtained from top leaves by keeping their bases dipped in water for a few hours before curing (Pal, Indian Tob., 1957, 7, 219; Garner, 174-77; Indian Tob. Monogr., 304-05; Kadam, Farm Bull. Indian Coun. agric. Res., No. 10, 1956, 60; Yegna Narayan Aiyer, 431-33; Mudaliar, 498-500; Sastry & Rao, Indian Tob., 1960, 10, 159).

After curing, the barn is allowed to cool down and the ventilators opened when the leaves absorb moisture from the air and become soft. They are then bundled into hands and bulked in small covered heaps for a few days. The heaps are opened and remade twice or thrice. The slight tinge of green present in some leaves disappears during this treatment. The leaves are then ready for grading and marketing.

Sun curing.—Many types of tobacco are sun cured in India. Entire plants are harvested and left to dry for some days in the field (ground curing). In some areas harvested leaves are made into heaps and periodically opened out to expose the leaves to dew and remade into heaps. Sometimes the leaves are



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FIG. 18—SUN CURING OF TOBACCO LEAVES

strung on poles or racks and exposed to the sun to dry (rack curing). A combination of ground curing and rack curing is sometimes followed as in the case of cigar and chewing tobacco of Madras. *Natu* tobacco of Andhra Pradesh is rack cured; the leaves are harvested with stalks, strung on jute threads and hung on scaffolds in the open for $1\frac{1}{2}$ –2 months; curing takes longer when the stalk is present and the smoking quality of the cured leaf is improved. Hookah and chewing tobaccos of Bihar, Uttar Pradesh and West Bengal are cured by wilting the leaves in the field, followed by alternate heaping and drying till the leaves become dark brown. In Punjab, hookah tobacco is cured for about a week in pits, 75–90 cm. deep, after initial wilting in the field. Pit curing is adopted to some extent in Coimbatore for chewing tobacco (Indian Tob. Monogr., 280–83, 318; Mudaliar, 501–04).

Air curing—Wrapper tobacco of West Bengal and *Lanka* tobacco of Andhra Pradesh are air cured. The green leaf of wrapper tobacco is graded according to size and strung on to sticks which are then transferred to barns in which the relative humidity is maintained at 70–80%: water is sprinkled inside the barn when required for controlling the humidity. The leaves turn yellow and then brown and the curing is completed in 5–6 weeks. The leaves of *Lanka* tobacco are strung on to ropes in a shed for 2–2½ months and

curing is completed in pits (Indian Tob. Monogr., 278–80, 335–36; Garner, 167–72).

Fire curing—Certain types of chewing tobacco are cured by smoking as in Ceylon. Only limited quantities are cured by this method in India. A peculiarity of this method is the treatment given to smoked leaves with salt water from sea or with a solution of jaggery to impart a distinct taste (Indian Tob. Monogr., 280, 358).

CHANGES DURING CURING

Freshly harvested leaf contains c. 85% of moisture, most of which (60–75%) is lost during curing. Respiration, translocation of constituents, and chemical changes due to oxidation and hydrolysis take place, chiefly during the yellowing stage of curing; a substantial loss in dry matter takes place, the loss varying from 5 to 10% in flue curing and up to 30% in air curing.

The leaf pigments undergo drastic changes during curing and the brilliant green of fresh tissue passes through various shades of yellow-brown. The yellow pigments become prominent following the degradation of chlorophyll during the yellowing period. The yellow colour is fixed in flue curing; in other curing processes, the pigments undergo further change and the final colour of cured leaf is that of complex condensation and polymerization products, primarily of the melanoidin and tannin types, involving the reaction of polyphenols, carbohydrates, amino acids and proteins.



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FIG. 19—AIR CURING OF LANKA TOBACCO



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FIG. 20—FERMENTATION OF CHEWING TOBACCO

The most important change during flue curing is the hydrolysis of starch into sugars; c. 90% of the starch is converted during yellowing. The concentration of reducing sugars increases during fixing and decreases during the subsequent stem drying. Sucrose is present in freshly cured leaf but is almost entirely inverted during storage before marketing. There are no significant changes in total nitrogen and nicotine content; ammonia and amides increase appreciably during yellowing, especially in low carbohydrate leaves.

Chemical and physical changes are much more extensive in leaves subjected to air curing. There is a substantial increase in water-soluble nitrogen compounds (amino acids and amides), followed by oxidative deamination of amino acids; the loss in total nitrogen during curing is c. 6%. Starch and sugars disappear almost entirely and a considerable portion of the malic acid is converted into citric acid. The changes are more pronounced in stalk-curing than in curing of primed leaves (Kirk & Othmer, XIV, 249-50; Garner, 399; Indian Tob. Monogr., 202-12; Sastry, *Indian Tob.*, 1951, 1, 245; Sastry, *Proc. Indian Acad. Sci.*, 1953, 38B, 125).

CHEMICAL COMPOSITION

The chemical composition of tobacco is greatly influenced by genetic and environmental factors. The nicotine content and aroma vary according to the variety or strain. Large variations occur within a given type not only from farm to farm but also in crops of different years. Seasons of deficient rainfall produce crops that are high in nicotine but low in total carbohydrates; excessive rainfall produces the opposite effects.

The composition of the leaves of an individual plant varies markedly with their position on the stem. In flue cured tobacco, the concentration of nicotine and nitrogenous constituents is maximum in the upper leaves and minimum in the centre and lower part of the stem; soluble sugars are most abundant in leaves at the centre; the concentration of non-volatile organic acids is high in the lower leaves and low in the central leaves. The potash content is about the same in all the leaves of the plant. In air cured tobacco, such as Burley and Maryland, the total nitrogen and soluble acids in the leaves increase from the base upwards; the concentration of nicotine and petroleum ether extractives is highest in the middle leaves and lowest in leaves at the base of the stem. The upper leaves are usually the most aromatic (Garner, 328, 430-31; Kirk & Othmer, XIV, 243-47; Darkis *et al.*, *Industr. Engng Chem.*, 1936, 28, 1214; Darkis & Hackney, *ibid.*, 1952, 44, 284).

The average moisture content of freshly harvested tobacco leaf is 80-90% and of dried processed leaf, 10-15%. Total organic constituents amount to 75-90% (moisture-free basis) and comprise carbohydrates, alkaloids and other nitrogenous substances, organic acids, polyphenols and pigments, oils and resins, enzymes and others. Over 200 compounds have been identified in tobacco leaf and a larger number in the smoke [Thorpe, XI, 646; Indian Tob. Monogr., 197; Kensler, *Ann. N.Y. Acad. Sci.*, 1960, 90(1), 43].

Tobacco contains 25-50% total carbohydrates, mainly reducing sugars, sucrose, starch, pectins, cellulose, lignin and pentoses. Dextrin, maltose, stachyose, rafinose, rhamnose, ribose, inositol, and sorbitol have been identified. Cigarette types are generally richer in carbohydrates than cigar types. Flue cured Indian tobacco contains: starch, 1-2%; reducing sugars, 5-16%; and sucrose, 7%; sucrose is hydrolyzed into reducing sugars during bulking. Air cured tobacco is poor in carbohydrates (Indian Tob. Monogr., 197-98, 211; Johnstone & Plimmer, *Chem. Rev.*, 1959, 59, 885).

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Pectic substances occur in the leaf in considerable quantities; free pectic acid and calcium magnesium pectate have been isolated. Acid hydrolysis of leaf pectins yields galacturonic acid, galactose, and arabinose; the pectins of stem are similar to those of leaf; root pectins yield on hydrolysis rhamnose, mannose, fructose, xylose and ribose, in addition to galactose and arabinose (Indian Tob. Monogr., 198; Johnstone & Plimmer, loc. cit.).

The nitrogen content of typical cigarette tobacco types grown in India is c. 2%; that of cigar tobacco is 4%. Proteins constitute the major component; amino acids, ammonia, amides and nitrates are present in smaller amounts. Two protein fractions have been isolated from the green leaf. The major fraction, which is a nucleoprotein, possesses auxin and phosphatase activities and is rapidly decomposed during curing; the second fraction, which also shows enzyme activity, is relatively more stable. The principal amino acids present in the green leaf are: alanine, α -amino-butyric acid, asparagine, aspartic acid, glutamine, lysine, phenylalanine, proline, serine, tryptophan and tyrosine. Nitrates are present in the midrib and veins; ammonia is also present in small amounts (Indian Tob. Monogr., 198; Johnstone & Plimmer, loc. cit.; Koenig *et al.*, *Science*, 1958, **128**, 533; Garner, 314).

Tobacco contains a high percentage of organic acids (20% or more), mainly malic, citric and oxalic acids. Malic and citric acids occur largely in the form of calcium, magnesium and potassium salts, while oxalic acid is present as the calcium salt. Several other non-volatile as well as volatile acids have been identified in tobacco; they include maleic, fumaric, lactic, malonic, terephthalic, succinic, glyoxylic, α -ketoglutaric, formic, acetic, β -methylvaleric, D-glyceric, *trans*-crotonic, propionic, methylethyl-acetic, possibly isobutyric, benzoic, and 2-furoic acids; some of these acids may arise as degradation products during the processing of leaf. In addition, fatty acids such as palmitic, oleic, linoleic and linolenic are reported. Tobacco leaf shows an acid reaction throughout the period of growth and development; cured products also show an acid reaction (Seshadri, Indian Tob., 1951, **1**, 199; Garner, 315; Johnstone & Plimmer, loc. cit.; Palmer, *Science*, 1956, **123**, 415).

Chlorophylls *a* and *b* are the dominant pigments in the growing leaf and, in most types, almost completely mask the yellow pigments present; the latter, however, contribute to the brilliance of the green colour. During curing, the chlorophyll concentration

rapidly decreases and the yellow pigments, carotene and xanthophyll, become prominent. Rutin also contributes to the yellow colour of the leaf. The carotenoids identified are β -carotene, neo- β -carotene, lutein, neoxanthin, violaxanthin and flavoxanthin. The dark colouration which commonly develops during air and sun curing is partly caused by the oxidation of polyphenols [Garner, 316; Weybrew, *Tobacco, N.Y.*, 1957, **144**(1), 18].

Tobacco contains several substances of the phenol, polyphenol and tannin classes, mostly in the form of glycosides. The principal polyphenols are rutin (quercitrin-3-rhamnosidogluicoside), and chlorogenic acid (3-caffeoquinic acid) and its isomers. Rutin occurs to the extent of c. 1% in green leaves but its concentration decreases during curing, more notably in air curing than in flue curing; air cured leaf contains little or no rutin. The concentration of chlorogenic acid remains almost unaffected during curing. Other polyphenols reported are quinic acid, shikimic acid, quercitrin, isoquercitrin, scopoletin (7-hydroxy-6-methoxycoumarin) and its 7-glucoside scopolin, aesculetin (6, 7-dihydroxycoumarin) and its 7-glucoside eichoriin, kaempferol glycosides, and three yellow flavones. The phenolic compounds present are caffeic acid, melleotic acid (4-hydroxycoumaric acid), phenol, guaiacol, eugenol, iso-eugenol, *p*-allylcatechol, *m*-cresol, and *o*-hydroxyacetophenone. Nearly sixty phenolic compounds have been distinguished in the extract of flue cured leaf. The phenolic constituents play an important role in the oxidation-reduction processes in the growing leaf and also influence the colour and, to some extent, the aromatic properties of cured leaf (Johnstone & Plimmer, loc. cit.; Jensen, *Industr. Engng Chem.*, 1952, **44**, 306; Dieterman *et al.*, *J. org. Chem.*, 1959, **24**, 1134; Runeckles, *Chem. & Ind.*, 1962, 893; Garner, 315).

The essential oils and resins present in the glandular hairs which cover the surface of leaves are mainly responsible for the characteristic aroma of tobacco. Freshly cured leaf has a rather flat, unpleasant odour and yields on burning an irritating, pungent smoke with a bitter flavour. The agreeable aroma of tobacco is developed in the course of ageing or fermentation. The aroma of tobacco varies in quality and strength with the type of tobacco, the edaphic and climatic factors and the conditions of fermentation. Aromatic or Oriental tobaccos are an important group derived from *N. tabacum* types, mainly grown in countries bordering on the eastern Mediterranean. They constitute nearly one-eighth of

world production and are characterized by small size of leaves, aromatic flavour, ready combustibility and good filling properties. They are increasingly used for blending (Garner, 316, 327; Darkis & Hackney, *Industr. Engng Chem.*, 1952, **44**, 284; Wolf, 10, 83, 192-94).

Tobacco resins are believed to be formed by oxidation and condensation of volatile oils; they constitute the less volatile compounds of the ether extract. Early work reported the isolation of three non-volatile, noncrystalline resin acids, viz. α -, β - and γ -tobaccic acids, an unsaturated alcohol ($C_6H_{10}O$, m.p. 219°) and an unsaturated dihydroxyalcohol ($C_9H_{16}O_2$, m.p. 86°). Recently ethanol-extracted tobacco resins were fractionated into soft resin, and hard resins A and B; it was shown that under the influence of light and air, the soft resin was converted into hard resins A and B. The soft resin fraction was composed of C_{29} - C_{31} hydrocarbon waxes, neo-phytadiene, polyene, C_{12} - C_{20} saturated and unsaturated fatty acids (occurring free or combined as glycerides or esters of sterols), solanesol (free or esterified with fatty acids) and sterols. It was suggested that hard resin A might be a polymerization product of the soft resin, whereas hard resin B was an oxidation product of hard resin A. The hard resins are mixture of complex substances which are usually viscous, odorous and coloured; no homogeneous components have been isolated (Garner, 317; Wolf, 192-94; Shimuk, III, 177-84; Hellier, *Chem. & Ind.*, 1959, 260; Reid & Hellier, *ibid.*, 1961, 1489; Swain *et al.*, *ibid.*, 1961, 435).

Accompanying the resins are several paraffins, generally designated as tobacco wax (m.p. 63°): heptacosane and hentricontane are the main components, homologues and isomers from C_{27} to C_{36} being present in small amounts. Examination of the sun cured Indian tobacco (*Meenampalayam* from Coimbatore) showed the presence of hentricontane, nonacosane and heptacosane, besides six other waxy compounds (Johnstone & Plimmer, loc. cit.; Divekar *et al.*, *Proc. Indian Acad. Sci.*, 1961, **54B**, 57).

Leaf enzymes play an important role in determining the biochemical changes that occur during curing. The enzymes distinguished in cured leaf are protease, lipase, emulsin, amylase, invertase, phosphatase, glycolase, pectase, ketone-aldehyde mutase, oxidase, peroxidase, catalase, and reductase (Indian Tob. Monogr., 201).

As compared with other crop plants, tobacco has a high mineral content (12-25% on dry wt. basis)

which varies with variety, the nature of soil, and the fertilizers used. Potassium and calcium constitute 50% or more of the ash; magnesium, phosphorus, sodium, silicon, chlorine and sulphur are present in appreciable quantities. Arsenic is present only in traces; other trace constituents identified in tobacco are aluminium, barium, boron, cesium, chromium, copper, iron, lead, lithium, manganese, rubidium, strontium, titanium, zinc and iodine. The mineral components of tobacco have a decided effect on the combustibility and other quality factors in the leaf (Garner, 317-18; Johnstone & Plimmer, loc. cit.).

Tobacco contains several miscellaneous substances which include an auxin resembling indole acetic acid, phosphatides, saponins, glycosides, ascorbic acid, vitamins of the B group, nucleic acids, solano-chromene, purines, tocopherols, and several sterols and their glycosides. Effect of curing on nicotinic acid, riboflavin, pantothenic acid, and thiamine contents of cigar tobacco has been reported. The sterol content (0.1-0.5%) varies with variety; stigmasterol, β -sitosterol, and γ -sitosterol are the major components; ergosterol occurs in small amounts. A glucoside of γ -sitosterol is reported to be present in Indian chewing tobacco. Sun cured variety of tobacco from Coimbatore showed the presence of a ketosteroid ($C_{30}H_{52}O$, m.p. $263-64^\circ$) and 4 sterols (including β -sitosterol and C_{27} - C_{29} sterols) and their glucosides (Johnstone & Plimmer, loc. cit.; Jensen, loc. cit.; Khanolkar *et al.*, *Science*, 1955, **122**, 515; Divekar *et al.*, loc. cit.).

Tobacco alkaloids—Tobacco contains several pyridine alkaloids (Table 11), of which nicotine (β -pyridyl- α -N-methyl pyrrolidine) is the most important. The total alkaloid content of different varieties of tobacco shows large variations. *N. tabacum* varieties usually contain 4% total alkaloids; the alkaloid content does not exceed 6%. *N. rustica* varieties may contain twice this amount; wild species have a lower alkaloid content than *N. tabacum*. Nicotine is the predominant alkaloid in *N. tabacum* and *N. rustica*; other bases occur to a very limited extent. Nornicotine is the main alkaloid in a large number of wild species of *Nicotiana* (cf. Table 1) and anabasine in *N. glauca* and a few wild species; nicotine is often present as a secondary alkaloid (Henry, 35; Garner, 314).

Nicotine is absent in mature seeds and appears in the seedling in the early stages of germination and is present in all parts of the plant. It is most abundant in the leaves; the blades contain more nicotine than the midribs; nicotine content increases towards the

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TABLE 11—ALKALOIDS AND OTHER BASES PRESENT IN TOBACCO*

Alkaloid	Formula	b.p.
<i>l</i> -Nicotine	C ₁₀ H ₁₄ N ₂	246°
Nicotyrine	C ₁₀ H ₁₄ N ₂	280°
Nicotimine	C ₁₀ H ₁₄ N ₂	255°
<i>l</i> -Nornicotine	C ₉ H ₁₂ N ₂	267°
<i>d</i> -Nornicotine	C ₉ H ₁₂ N ₂	..
Piperidine	C ₅ H ₁₁ N	106°
Pyrrolidine	C ₅ H ₉ N	88°
N-Methylpyrrolidine	C ₅ H ₉ N	80°
2,3'-Dipyridyl	C ₁₀ H ₁₂ N ₂	294°
<i>l</i> -Anabasine	C ₁₀ H ₁₄ N ₂	276°
N-Methyl- <i>l</i> -anabasine	C ₁₁ H ₁₆ N ₂	268°
<i>l</i> -Anatabine	C ₁₀ H ₁₂ N ₂	146°/10 mm.
N-Methyl- <i>l</i> -anatabine	C ₁₁ H ₁₄ N ₂	120°/1 mm.
Nicotoine	C ₈ H ₁₁ N	208°
Necotelline	C ₁₀ H ₁₁ N ₃	148° (m.p.)
Myosmine	C ₉ H ₁₀ N ₂	45° (m.p.)

Nicotimine is considered to be an impure substance and occurrence of nicotoine is doubtful. Simpler bases, namely ammonia, methylamine and isoamylamine, and two ketones, viz. 3-pyridylmethylketone and 3-pyridylethylketone are also reported in tobacco.

* Manske & Holmes, I, 257; VI, 132; Johnstone & Plimmer, *Chem. Rev.*, 1959, **59**, 885.

tip and the margin. Steady accumulation of nicotine goes on through the growing period reaching the maximum at or about the time of flowering. There is a fall in nicotine content after the leaf reaches full maturity. It has been shown that nicotine is synthesized from ornithine and nicotinic acid, mainly in the root system and is then translocated to the leaves. It is reported that the synthesis of nicotine occurs in leaves and stems when nitrogen is supplied to the tissue in the form of ammonium sulphate or potassium nitrate. The total nicotine content of the plant is distributed as follows: leaves, 64; stems, 18; roots, 13; and flowers, 5%; mature seeds are practically free of alkaloids [Garner, 442-43; Wolf, 188; Manske & Holmes, I, 35-37, 229-35; Dawson *et al.*, *Ann. N.Y. Acad. Sci.*, 1960, **90**(1), 7; Bose *et al.*, *Indian J. med. Res.*, 1956, **44**, 81].

The concentration of nicotine in tobacco varies with variety, climatic conditions and methods of cultivation. Considerable work has been done on breeding and selection of types with low nicotine and protein contents for the use of smokers, and of types giving high yields of nicotine for the manufacture of insecticides and nicotinic acid. Crops produced in hot, dry years have generally a higher nicotine content than those grown in cold, wet years; application of

nitrogenous fertilizers to the soil tends to raise the nicotine content. Table 12 gives the nicotine content of different types of Indian tobacco (Garner, 442-43; Henry, 47; *Biol. Abstr.*, 1951, **25**, 1093).

Nicotine is present in tobacco mainly as salts of organic acids and there is a close parallelism in the plant between nicotine and citric acid; the salts of nicotine are dextro-rotatory. Two nicotine glycosides, tabacin and tabacilin, have been reported but not confirmed. Nicotine is a colourless liquid which turns brown on exposure to air and acquires a characteristic tobacco odour; it has a sharp, burning taste. It is insoluble with water in all proportions at temperatures below 60° and above 210°, but is less soluble between these temperatures. It is easily volatilized

TABLE 12—NICOTINE AND ASH CONTENTS OF IMPORTANT TYPES OF CURED TOBACCO LEAF PRODUCED IN INDIA*

Type	Nicotine (% moisture-free basis)	Ash
<i>N. tabacum</i>		
CIGARETTE		
Virginia flue cured		
Guntur	1.22-2.96 (2.14)	13.87-16.66 (15.26)
Mysore	0.60-1.17 (0.76)	11.44-13.31 (12.61)
Natu sun cured		
Guntur	1.38-3.00 (2.04)	17.37-19.96 (18.44)
CIGAR		
Madras	0.65-3.44 (2.25)	18.83-22.55 (21.06)
W. Bengal	2.76-3.49 (3.13)	16.04-17.93 (16.98)
CHEROOT		
Madras	4.25-5.26 (4.75)	15.97-18.88 (17.43)
BIDI		
Gujarat	2.30-3.78 (3.13)	16.55-23.81 (18.91)
Nipani	2.96-5.01 (3.90)	16.00-21.24 (18.60)
HOOKAH, CHEWING & SNUFF	1.63-4.13 (3.14)	16.18-22.48 (18.97)
<i>N. rustica</i>		
HOOKAH, CHEWING & SNUFF		
W. Bengal	4.58-7.39 (6.10)	19.73-23.79 (22.35)
U.P. & Punjab	2.00-4.63 (3.82)	7.36-27.73 (22.63)

* *Marketing of Tobacco in India, Marketing Ser.*, No. 123, 1960, 224-26, 72.

No variety is grown to any appreciable extent solely for chewing and snuff tobacco; generally hookah varieties are consumed for these purposes.

Figures in brackets indicate mean value.

with steam and on oxidation yields nicotinic acid (Manske & Holmes, I, 229, 235; Johnstone & Plimmer, loc. cit.).

UTILIZATION

The bulk of tobacco produced in India is used for smoking in the form of cigarette, bidi, cigar, cheroot and *chuttas* and in pipe and hookah. Large quantities are also consumed for chewing and for snuff. With the exception of cigarettes, which are manufactured in factories, all others are produced in India on a cottage industry basis. Tobacco was formerly much employed in medicine as sedative, antispasmodic, and vermifuge, and in the treatment of various gastrointestinal disorders, skin diseases, and local affections. Its use has been, however, superseded by safer and more efficacious remedies : overdoses of tobacco may result in severe fatal nicotine poisoning. Tobacco is sometimes used as a veterinary anthelmintic (Patel, *Indian Tob.*, 1960, 10, 35 ; Larson *et al.*, 78-96).

Tobacco powder and extracts of tobacco have been long used as agricultural insecticide or in the eradication of animal pests such as lice and ticks. Tobacco waste comprising dust, midribs and stems, and damaged tobacco are utilized for the extraction of the active principle nicotine which, usually in the form of sulphate, is widely used as an insecticide. Nicotine is used also in the production of synthetic nicotinic acid and nicotinamide. Stems and stalks, unextracted or after the extraction of nicotine, are useful as manure ; they have a high potash content (Thorpe, XI, 644-45 ; Kirk & Othmer, XIV, 257 ; Blanck, 129).

The seeds of tobacco plant are free of the toxic alkaloid, nicotine, and are used for feeding livestock. Ripe pods of the plant, though readily eaten by sheep and goats in Andhra, are generally burnt along with the stalks which serve as fuel in this tract. The seeds yield a semi-drying oil which after refining is suitable for edible purposes and for use in paints and varnishes. The seed cake is rich in protein and finds use as a feeding stuff for farm stock. It also serves as a nitrogenous manure (Rao & Narasimham, *Indian J. agric. Sci.*, 1942, 12, 400 ; Eckey, 738).

Tobacco absolute has in recent years been prepared from French tobacco by extracting the leaves with volatile solvents. It is commonly employed as a colourless resinoid and is invaluable for imparting an attractive nuance in modern fashionable perfumes. A method using 95% ethanol has been developed for the extraction of "essence" from tobacco stems ; the

fragrant fraction could be used to improve the lower grade tobaccos or to impart a tobacco aroma to paper, wood, or similar materials used in packing tobacco products (Poucher, I, 402 ; Badgett & Woodward, *Bur. agric. industr. Chem., U.S. Dep. Agric.*, AIC-298, 1951).

QUALITY VARIATIONS IN COMMERCIAL TOBACCO

The commercial value of tobacco depends fundamentally on its suitability for specific purposes, involving several elements of quality such as colour, body, conformation, texture, elasticity, aroma, etc. Chemical methods and physical measurements are now widely used to supplement empirical methods for the estimation of tobacco quality. Since the elements of quality differ greatly in the various types of leaf, separate standards for corresponding chemical composition are required for each distinctive type. For instance, the flue cured and Maryland types are used for blending in the same cigarette, but whereas a high content of reducing sugar is an indication of good quality in flue cured leaf, it would indicate an abnormal product in the case of Maryland tobacco (Garner, 320, 438).

The percentage of nicotine, and the proportion which it comprises of the volatile base fraction, have important influence on taste quality of smoking products. In flue cured tobacco, a distinctly high nicotine content ($>3\%$) is usually objectionable but a low concentration ($<1.5\%$) also will be unsatisfactory to the average cigarette smoker. The combustion characteristics are important in determining the composition and palatability of smoke. It is desirable that tobacco burns slowly and completely. Potassium favours the fire-holding capacity whereas chlorine, sulphur, and nitrogen tend to retard the combustion. The desirability of flue cured tobacco for cigarette use is, within certain limits, directly proportional to reducing sugars and inversely to the total nitrogen ; cigar types, on the other hand, are almost free of carbohydrates and are rich in nitrogen. The volatile oils of tobacco are the principal aromatic fraction, the total quantity of oil being less important than its composition. The alcohol soluble resins of tobacco are desirable for their flavour and their palliative effect in smoking products. The practice of blending tobacco depends upon the balancing of the nitrogenous, carbohydrate, mineral, and aromatic components in the product (Kirk & Othmer, XIV, 248 ; Garner, 441).

There are characteristic differences in average

TABLE 13—CHEMICAL COMPOSITION OF LEAF LAMINA IN DIFFERENT TYPES OF INDIAN TOBACCO*
(% moisture-free basis)

Type	Place grown	Soluble ash	In-soluble ash	Ca- lum (CaO)	Magne- sium (MgO)	Potas- siu- (K ₂ O)	Phos- phorus (P ₂ O ₅)	Total nitro- gen	Total sugars	Chlo- rine	Nico- tine
Virginia flue cured, Harrison Special**	Gujarat	16.58	2.48	3.82	1.98	1.14	1.58	1.50	18.82	1.76†	1.20
Cigar Tobacco	Vedasandur (Madras)	24.50	n.a.	5.72	2.19	6.61	0.66	3.55	n.a.	3.63	1.77
Bidi Tobacco**	Gujarat	21.84	5.86	5.42	1.68	2.46	1.18	2.84	6.64	4.32†	8.20
Bidi Tobacco**	Mysore	21.32	1.98	6.18	2.78	2.74	0.88	3.22	5.82	3.14†	6.50
Wrapper Tobacco	Dinhata (West Bengal)	21.66	n.a.	5.42	2.03	6.48	0.84	3.31	n.a.	0.30	1.33
Natu Tobacco	Andhra Pradesh	12.65	1.93	5.89	1.77	1.85	0.44	2.64	7.67	2.34	3.39
Lanka Tobacco	do.	13.03	10.11	5.27	1.46	1.81	0.33	3.52	1.20	0.27	5.12
Hookah Tobacco	Punjab	17.57	14.60	4.88	2.08	4.19	0.75	2.98	0.43	2.17	2.87
Hookah Tobacco	Pusa (Bihar)	19.77	6.34	9.38	1.17	3.35	0.76	4.12	0.89	0.57	4.21
Hookah Tobacco	Dinhata (West Bengal)	15.03	7.86	4.92	1.66	3.36	0.92	4.24	0.39	0.26	6.02
Chewing Tobacco	Vedasandur (Madras)	14.58	5.70	4.59	2.16	4.83	1.02	4.51	0.36	2.59	5.33
Chewing Tobacco	Pusa (Bihar)	17.30	9.79	7.30	2.27	3.20	0.67	4.19	0.57	2.40	4.64

* Information from the Director, Cent. Tob. Res. Inst., Rajahmundry; Indian Tob. Monogr., 225.

** Virginia tobacco, bidi tobacco from Gujarat, and bidi tobacco from Mysore also contain, respectively: volatile oil, 0.01, 0.86, 0.88; wax, 0.98, 0.98, 0.66; resin, 1.38, 4.86, 2.74; ether extr., 5.28, 8.16, 5.48; and alcohol extr., 27.7, 22.18, 18.64%, moisture-free basis.

† Value expressed as chloride (NaCl). n.a.—not available.

TABLE 14—CHEMICAL COMPOSITION OF INDIAN, AMERICAN AND NEW ZEALAND FLUE CURED TOBACCOES*
(% moisture-free basis)

	Indian (Harrison Special)	American (Type 13)	New Zealand (Harrison Special)
Starch	0.97– 1.47	6.38	11.90
Reducing sugars	3.57– 7.69	18.94	23.65
Total sugars, as glucose	9.01–15.29	28.33	
Total nitrogen	1.91– 2.28	1.22	1.45
Protein	2.71– 4.78	3.70	4.16
Ammonia	0.03– 0.05		
Amides and amino acids	4.32– 6.10	2.02	2.51
Nicotine	1.12– 1.59	1.12	1.47
Ash	14.77– 20.43	10.71	10.15

* Indian Tob. Monogr., 229.

composition between the principal types of tobacco. Table 13 gives the chemical composition of different types of tobacco produced in India. The cigarette and cigar tobaccos of Indian origin are regarded as inferior to those produced in the U.S.A.

Flue cured tobacco—Flue cured types are characterized by high sugar content, low to medium nitrogenous and acid constituents, and medium content of nicotine. However, very high levels of sugar produce trashy leaf with poor fire-holding capacity and aroma. Indian leaves generally contain less total sugars and more nitrogen than what is desirable, as indicated by comparison with the American leaf (Table 14). The value for the nitrogen complex† is much higher in the Indian leaf than in the foreign tobacco, which shows that the hydrolysis of proteins during curing is more extensive in the Indian tobacco probably due to the unfavourable chemical and enzymic make-up of the leaves.

† The nitrogen complex is obtained by multiplying the difference between the total nitrogen and the sum of the protein, nicotine, and ammonia nitrogen by 4.7, the conversion factor for asparagine. It indicates the content of amino acids and amides.

The inferior quality of Indian tobacco appears to be due, to a large extent, to the dry conditions obtaining during the growth period and the heavy black soils on which it is raised. It may perhaps be possible to produce tobacco with required sugar and nitrogen contents by changing the farming conditions, i.e. by growing tobacco on lighter soils, under rain or irrigation ; for instance, the sugar content of *Harrison Special*, grown in New Zealand, has been raised to the level present in the American leaf. An alternative is to evolve a special, flue cured variety suited to the conditions prevailing in the tobacco growing tracts (Indian Tob. Monogr., 222).

Analysis of the Indian flue cured tobacco showed that quality of the cured product was greatly influenced by the starch and moisture contents of the green leaf ; leaves with a fairly good amount of moisture (80-85%) and starch (c. 13%) tend to produce good grades of tobacco on curing. It has been suggested that the initial starch content may be used as an index of the curability of the different flue cured varieties. Fertilization of the crop with farm-yard manure or N.P.K. appears to decrease total sugars and increase amide or total nitrogen ; N.P.K. treatment increases the potash content slightly (Sastry, Proc. Indian Acad. Sci., 1953, 38B, 125 ; Sastry, Indian Tob., 1951, 1, 249 ; Sastry & Sitapathi, J. sci. industr. Res., 1959, 18A, 472 : Sastry, ibid., 1959, 18A, 566).

Studies on the individual leaves of *Harrison Special* plants, selected at random, have shown that the bottom four leaves are low in starch, somewhat high in nitrogen and low in sugars in the cured leaf. The middle 8-9 leaves are high in starch, sugars, and nitrogen, whereas the uppermost 5 or 6 leaves are low in starch, high in nitrogen, and low in sugars in the cured leaf. The concentration of these constituents shows year to year differences due to variations in rainfall (Sastry & Kadam, Indian J. Agron., 1959-60, 4, 1).

Cigar tobacco—The varieties commonly used in the manufacture of high grade cigars and cheroots in India are *Vellai vazhai* and *Karu vazhai*, the chemical compositions of which are summarized in Table 15. There are no separate filler and binder varieties grown in India ; torn and damaged leaves are used as filler and the others as binder. Cigar leaf grown in India generally contains less total nitrogen than the American leaf (Table 15). Its nicotine content is intermediate between the American filler and binder leaves ; this suggests that the fermentation procedures

practised in India are less severe than what is required for the filler and more severe than needed for the binder varieties. This can be obviated by evolving separate filler and binder varieties. Indian tobacco contains more of mineral salts (potassium, calcium, and magnesium) than the American tobacco, because of the highly calcareous soils on which cigar tobacco is grown in India. Further, it has an undesirably high content of chlorine (2-4% compared to the maximum permissible limit of 1% in American cigar tobacco) due to the saline well water used for irrigation ; the use of water containing less chlorine is recommended. Heavy nitrogen fertilization was found to improve the fire-holding capacity and general smoking quality of the *Vellai vazhai* variety (Indian Tob. Monogr., 27, 223-24 ; Ananth, Allahabad Fmr., 1959, 33, 420).

Growth and quality of cigar tobacco leaf (*Vellai vazhai*) as influenced by its position on the stem have been investigated. It was observed that when the plant was topped leaving 14 leaves on the stem, the bottommost 4 leaves, which were more or less fully developed at the time of topping, developed very little afterwards and the new growth was mostly confined to the upper half of the plant. Leaves at positions 5 to 12 had the best burn, leaves at positions 13 and 14 had medium burn, while leaves at positions 1 to 4 had the poorest burn. Considering the general quality of the leaf, it was observed that leaves at positions 5 to 14 are of better quality than those at positions 1 to 4.

TABLE 15—CHEMICAL COMPOSITION OF CURED INDIAN AND AMERICAN CIGAR TOBACCO*
(% moisture-free basis)

	Indian		American	
	Karu vazhai	Vellai vazhai	Pennsylvania seed leaf filler	Connecticut broad leaf binder
Total nitrogen	3.81	3.55	4.04	5.19
Protein	10.50	11.81	13.50	9.08
Nicotine	2.49	1.77	1.04	3.43
Other soluble nitrogen	1.70	1.35	1.70	3.15
Ash	23.50	24.50	..	17.83
Chlorine	2.75	3.63	..	0.40
Potash (K ₂ O)	5.44	6.61	..	4.63
Calcium (CaO)	5.41	5.72	..	4.95
Magnesium (MgO)	2.54	2.19	..	0.89

* Indian Tob. Monogr., 223.

tions 1 to 4. The poor quality of the lowermost four leaves may be due to their incomplete curing, fermentation and depletion of their contents by translocation to the upper leaves (*Tejwani et al., Indian J. agric. Sci.*, 1958, **28**, 199).

Certain interesting correlations have been observed between the burning quality and chemical composition of the Indian cigar and cheroot tobacco; potassium and calcium had a positive influence whereas nitrogen, chlorine and magnesium had a negative influence on the burning of cheroot. It has been noted that in the case of Connecticut cigar leaf, a crop grown during wet season had a better fire-holding capacity than that produced during dry season; good burning tobacco had a higher alkalinity of ash (*Sastry & Kurup, J. sci. industr. Res.*, 1958, **17B**, 499; *Indian Tob. Monogr.*, 220).

Bidi tobacco—The tobacco used in the bidi manufacture differs markedly from the flue cured Virginia tobacco, particularly in the contents of nicotine, nitrogen, carbohydrates, and volatile oils (Table 13). Among the types of tobacco grown in India, bidi tobacco has generally the highest nicotine content, values for some of the improved varieties being as follows: *Surti-20*, 5.59; *Saijpuriu-57*, 3.89; *Keliu-49*, 6.62; and *Gandiu-6*, 6.03%. Experiments have shown that in some bidi varieties nicotine content could be raised to over 8% with the application of nitrogen fertilizers. Nicotine and total nitrogen were increased to a greater extent by the use of inorganic fertilizers than by organic manures, whereas carbohydrate content was higher when the source of nitrogen was organic. In general, ammonium sulphate and groundnut cake gave superior results among the fertilizers tried. The presence of salt in irrigation water tended to decrease the nicotine and starch contents of tobacco. The quality of bidi tobacco is influenced most by percentages of nitrogen and calcium; high nitrogen and low calcium contents have favourable effects. The upper five leaves of the plant produce a better grade bidi tobacco than the lower five leaves (*Indian Tob. Monogr.*, 224-27; Patel, *Indian Tob.*, 1961, **11**, 19).

Development of spangles in mature leaf is an important criterion of quality in bidi tobacco and is associated with marked changes in chemical composition. In growing leaf, the total carbohydrates attain maximum concentration just before spangling; thereafter their content diminishes throughout the period of spangling and the minimum is reached at the time of harvest. Wax and resins increase till

TABLE 16—COMPOSITION OF DIFFERENT GRADES OF BIDI TOBACCO*
(% moisture-free basis)

	<i>Bhukka</i>	<i>Geran</i>	<i>Galia</i>	<i>Lakda</i>
Moisture	6.30	5.82	5.68	5.96
Nitrogen	2.24	2.32	1.96	1.26
Nicotine	7.91	5.28	6.97	0.965
Starch	6.22	2.22	1.85	2.81
Total sugar, as reducing sugars	6.25	3.12	3.75	3.70
Non-reducing sugars	4.75	2.11	2.80	2.28
Reducing sugars	1.25	1.00	0.80	1.30
Total ash	17.50	20.03	23.08	21.35
Acid insoluble ash	3.52	1.40	4.08	4.28
Calcium (CaO)	6.13	7.51	7.36	7.74
Magnesium (MgO)	1.89	1.81	2.18	2.44
Phosphorus (P ₂ O ₅)	0.85	0.47	0.59	0.82
Sodium (Na ₂ O)	0.136	0.192	0.195	0.322
Potassium (K ₂ O)	0.94	0.846	0.882	1.09
Chlorine (NaCl)	0.61	1.34	0.789	1.15

* *Indian Tob. Monogr.*, 229.

the appearance of spangles but when the leaf attains maturity they show some decrease and the surface becomes dry. The total nitrogen, nicotine, and chlorine continue to increase till the full development of spangles.

Bidi tobacco is sold in the form of flakes classified into four separate grades, viz. *bhukka* (leaf pieces), *lakda* (midribs), *geran* (small piece of leaf and secondary veins adhering to midrib after *bhukka* collection), and *galias* (sand leaves); they represent respectively 55-60%, 17-20%, 8-10%, and 10-15% of the total produce; the proportions varying according to variety, method and time of harvesting, and curing. *Bhukka* is considered the best grade and is the richest in nicotine, starch and total sugars (Table 16). Examination of several samples of commercial bidis showed that the ratio of tobacco to wrapper leaf by weight varied from 0.57 to 1.48; nicotine content of tobacco varied from 2.35 to 6.31%, and potash from 0.34 to 0.98%. The lamina in inferior bidis appeared to be adulterated (Patel, loc. cit.; *Indian Tob. Monogr.*, 226-30, 319-21).

Hookah tobacco—Chemistry of hookah and snuff tobaccos has not received much attention. Examination of commercial samples of hookah tobacco show-

ed that the nicotine content ranged from 0.74 to 6.01% in the raw product. *N. rustica* varieties have a higher nicotine content than *N. tabacum* varieties (Table 12). Application of nitrogenous manures and desuckering had a favourable influence on the nicotine content. It is believed that the plants irrigated with water from particular wells yield tobacco of superior quality. Analysis of water from such wells in Rohtak and Gurgaon districts showed that it was rich in chlorides, with appreciable quantities of nitrates (Indian Tob. Monogr., 230).

Snuff tobacco—Raw snuff tobacco grown in the Punjab contains 3.2–4.48% nicotine, 3.9–7.7% starch, and 8.5–13.0% other carbohydrates. In the processed product, the nicotine content is 0.42% in the inferior grades and 0.9–1.5% in the superior snuff. The greater part of sugars and hemicelluloses in moistened snuff powder is consumed during the early stages of fermentation; the later stage of fermentation is marked with a rise in the pH value and an increase in the free nicotine content (Indian Tob. Monogr., 230).

PHYSIOLOGICAL EFFECTS

Tobacco acts as a local irritant. Used as snuff, it excites violent sneezing and a copious secretion of mucus; on chewing, it irritates the mucous membrane of the mouth and increases the flow of saliva. In large doses or in persons not used to it, tobacco produces severe nausea, sometimes vomiting, accompanied with profuse perspiration, and great muscular weakness (U.S.D., 1955, 1904).

The pharmacological activity of tobacco is due almost entirely to its content of nicotine which is a powerful and rapidly acting poison. Toxic doses of nicotine produce extreme nausea, vomiting, evacuation of bowel and bladder, muscular tremors and convulsions; 40 mg. orally taken has been fatal for human beings. The base is rapidly absorbed through mucous membranes and intact skin, but the salts (e.g. sulphate) are absorbed very slowly. The dominant physiological action of nicotine is exerted on the autonomic ganglia and certain medullary centres, especially the emetic centre and the respiratory centre, which are by small doses primarily stimulated and by large doses secondarily depressed. The primary stimulation induces a transient rise in the blood pressure, slowing of the heart, deeper respiration, and increase in salivary and other secretions; with secondary depression, there occurs a fall in the blood pressure, rapidity of the pulse, irregularity of

the respiration, and paralysis of secretion. With fatal doses, death occurs usually due to cessation of respiration through paralysis of the phrenic nerve. *d*-Nornicotine and anabasine closely resemble nicotine in action but are more toxic. Myosmine is less toxic than nicotine but more active on isolated guinea-pig intestine. The *I*-forms of nicotine and nornicotine are more potent than the *d*- or *dl*-forms [U.S.D., 1955, 1904–05; Merck Index, 719; Travell, *Ann. N.Y. Acad. Sci.*, 1960, 90(1), 13; Comroe, *ibid.*, 1960, 90(1), 48; Henry, 50; Manske & Holmes, V, 118].

There is no evidence to show that moderate smoking is injurious to health but a high incidence of coronary heart disease has been noticed among heavy smokers; it is still uncertain whether smoking itself or the emotional stress that leads to smoking is the causal factor. The amount of nicotine entering the mouth through smoke has been variously estimated as between 0.2 and 8.5 mg. per cigarette and that absorbed up to 3.3 mg.; values for cigarette tar vary from 10 to more than 20 mg.; use of filter-tip cigarettes or holders containing filters decreases the amounts of nicotine and tar that reach the mouth. The effects of nicotine on heart rate, blood pressure, and vasoconstriction are, however, evanescent in character and subside within 10–30 minutes following cessation of smoking. Nicotine is quite rapidly detoxified in the body and there is no cumulative effect. Studies have shown that virtually all of the nicotine and its metabolites are eliminated in the urine, about 10% being in the form of unchanged nicotine and the remainder as products of biotransformation (*Sci. News Lett., Wash.*, 1962, 82, 3; U.S.D., 1955, 1904; Kirk & Othmer, XIV, 259).

A strong statistical relationship has been established between excessive and prolonged use of tobacco, especially cigarettes, and the induction of lung cancer. It has been found that the cases of lung cancer are more common among cigarette smokers as compared with pipe or cigar smokers, whereas lip cancer is more prevalent among the latter. The probable role of tobacco as a causative agent in cancer is receiving wide study. Among the several hundred constituents identified in the tobacco smoke are the potent carcinogen 3,4-benzpyrene and a number of other carcinogens of the same class of polycyclic aromatic hydrocarbons; they are, however, present in traces (1 p.p.m. or less) and it is uncertain if such minute concentrations would be harmful. It has recently been shown that cigarette smoke also contains substances (including phenols and certain long

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chain compounds) known as co-carcinogens or tumour promoters which, acting in conjunction with a carcinogen, increase its potency. A neutral fraction that produces cancerous lesions when applied to the skin of mice has been isolated from cigarette tar. There is, however, no evidence that implicates the alkaloids of tobacco for its supposed carcinogenic action [Carruthers, *Discovery*, 1962, **23**(5), 8 ; U.S.D., 1955, 1905 ; *Chem. Engng News*, 1956, **34**, 2242].

TOBACCO LEAF BY-PRODUCTS

Large quantities of waste material comprising rejected leaves, broken bits of lamina, midribs, stalks and stems accumulate both in the field and in the factories utilizing tobacco leaves. An efficient utilization of these products and also of tobacco seeds is of considerable economic importance.

Nicotine—Nicotine is by far the most important by-product derived from tobacco waste. It is extensively employed as an agricultural insecticide ; in recent years it has been partially replaced by synthetic organic phosphates. It has been used for combating animal pests, such as lice, gadflies and ticks. Nicotine is also used in the manufacture of nicotinic acid and nicotinamide. Recently it has been employed in assessing supra-optico-hypophyseal or peripheral sympathetic nerve functions or integrity (*Res. & Ind.*, 1956, **1**, 161 ; Kirk & Othmer, XIV, 257 ; Larson *et al.*, 796).

Analysis of tobacco waste from various sources in India showed that the average nicotine content varied from 1 to 3%. Nicotine can be recovered by steam-distillation, water extraction, organic solvent extraction and ion-exchange methods. A simple and economic process, by which c. 95% of the nicotine present in tobacco waste can be recovered, has been developed at the National Chemical Laboratory, Poona. The waste material, after pulverizing and liming, is extracted with salt solution, and the resultant broth brought to a pH 11–11.5 to liberate all the nicotine by the addition of lime and soda ash. The broth is next extracted with kerosene in a specially designed column, and the kerosene extract reacted with dilute sulphuric acid to produce nicotine sulphate of commercial strength (40%). Commercial exploitation of this process has commenced at Guntur (Gedeon & Goswami, *Indian Tob.*, 1952, **2**, 77 ; Indian Pat., 45,666, 46,994, 1953 ; Gedeon, *J. sci. industr. Res.*, 1951, **10A**, 153).

Nicotine is classed as a contact insecticide, but appears to act principally as a fumigant and some-

times as a stomach poison. It is effective against a number of vegetable and fruit pests, particularly the soft-bodied and minute insects including aphids, white flies, leaf hoppers, thrips, red spiders, snails, slugs, and cabbage butterfly larvae. Nicotine is used in the form of sprays (0.6–1.0%) and dusts (up to 4% nicotine), for the manufacture of which pure nicotine or more commonly nicotine sulphate (40%) is used. It is not persistent, and at the high dilutions commonly used it does not leave dangerous traces in products for human consumption ; precautions must, however, be taken by those directly handling the alkaloid. Hookah water containing dissolved nicotine is also an effective insecticide (*Colon. Pl. Anim. Prod.*, 1950, **1**, 95 ; Mahant & Pandit, *J. sci. industr. Res.*, 1948, **7A**, 362 ; Thorpe, XI, 645 ; Bal *et al.*, *J. Sci. Club, Calcutta*, 1952–53, **6**, 14).

Other uses—Tobacco scrap is used in appreciable quantities in Madras for the manufacture of snuff. Tobacco stems, after rolling and cutting, are employed in some countries for incorporation in tobacco blends. Processes have been developed for reconstitution of ground tobacco into a sheet for use in smoking products. Extracts of tobacco stems and waste have been used for flavouring low grade tobacco. The utilization of waste and stems for the recovery of organic acids, essential oil, pectin, rutin, resins suitable for coatings and plastics, wax for soap, and fibre for making insulating boards, has been investigated but has not come into commercial use. A moulding composition with thermoplastic properties has been prepared from the stalks. The fibre obtained from stems is weak and brittle for textile purposes but may find use in paper making (Mahant & Pandit, loc. cit. ; Kirk & Othmer, XIV, 257–58 ; Copley *et al.*, *Chem. Engng News*, 1942, **20**, 1220).

The midribs and stems, and the dried tobacco residue from the nicotine extraction plant contain appreciable amount of potassium as well as some nitrogen and phosphorus ; they find use as fertilizer. The stems contain on an average 6.79% K₂O, 2.08% N, and 0.61% P₂O₅. In Mysore, tobacco scrap and waste have been used as manure after composting. The stalk applied along with green manure to paddy also gave good results [Blanck, 129 ; Nasiruddin, *Indian Fmg. N.S.*, 1959–60, **9**(4), 21].

TOBACCO SEED

The seeds, which are light brown to black in colour, are tiny and tough in texture. They are free from nicotine and can be used as nutritious feed for

cattle ; before feeding, the seeds should be soaked in water and ground into a paste. Analysis of Virginia tobacco seed from Guntur gave the following values: moisture, 6.05 ; crude protein, 23.88 ; true protein, 22.80 ; ether extr. (fat), 35.77 ; carbohydrates, 13.77 ; fibre, 16.77 ; ash, 3.76 ; calcium, 0.15 ; potassium, 0.78 ; and phosphorus, 0.47%. Choline, betaine, adenine, guanine, allantoin, tannin, and resin are present in the seed. The polyphenols reported are rutin, scopoletin, scopolin, and chlorogenic acid (Garner, 309, 313 ; Rao & Ramanayya, *J. sci. industr. Res.*, 1948, **7B**, 87 ; Rao & Narasimham, *Indian J. agric. Sci.*, 1942, **12**, 400 ; *Indian Tob.*, 1961, **11**, 192).

A globulin has been isolated in crystalline form ; its amino acid composition is as follows: arginine, 16.1 ; histidine, 2.2 ; lysine, 1.6 ; tyrosine, 4.1 ; tryptophan, 1.5 ; phenylalanine, 5.7 ; cystine, 1.1 ; methionine, 2.2 ; threonine, 4.2 ; leucine, 10.5 ; isoleucine, 5.3 ; and valine, 6.7 g./16 g. N. Lysine is the limiting amino acid. The total seed protein at 10% level of intake has a biological value of 51.4% and a digestibility co-efficient of 78% (Garner, 313 : Kuppuswamy *et al.*, 83, 87, 92).

Tobacco seed oil—Tobacco seeds contain 33-41% of a semi-drying oil which is free from any toxic substances. The oil is extracted by the cold-drawn process in country wooden mills or by the hot-drawn process in hand presses. The cold-drawn oil from washed seeds is pleasant smelling, with an agreeable taste, and has properties similar to good quality gingelly oil ; the hot-drawn oil, however, possesses a slightly bitter taste. The extraction of oil requires high pressure, and bulk of the seeds are now crushed in specially designed expellers ; only limited quantities are extracted in hand presses. Average oil yield is 25% from expellers and 23% from hand presses (Eckey, 738 ; Rao & Narasimham, loc. cit. ; Patel, *Indian Tob.*, 1952, **2**, 25).

The oil content of different types of tobacco seeds does not show much variation. The percentage of oil in seeds of some of the *N. tabacum* types is as follows: *Gold Dollar*, 40.20 ; *White Burley*, 41.10 ; *Harrison Special*, 39.24 ; *Chatham*, 36. *Gandiu-6*, 38.80 ; *Keliu-49*, 39.30 ; *Saijpuriu-57*, 39.40 ; *Val monnai*, 40 ; *Vellai vazhai*, 38 ; *Natu*, 37 ; and *Surti-20*, 37. The oil content of seeds of *N. rustica* types is nearly same (Patel, loc. cit. ; Kapadia & Aggarwal, *J. sci. industr. Res.*, 1954, **13B**, 352).

The unrefined oil varies from yellow to green or brown in colour and may have little odour or a strong smell of tobacco. It can be refined to a

colourless and odourless oil by common refining methods. The characteristics of the oil are as follows: sp. gr.¹⁵, 0.923-0.925 ; n_D²⁰, 1.474-1.483 ; sap. val., 186-197 ; iod. val., 129-142 ; R.M. val., <0.5 ; Polenske val., 3 ; and unsapon. matter, <1.5%. It has the following fatty acid composition: saturated (palmitic and stearic), 10-15 ; oleic, 15-30 ; and linoleic, 55-75%. Small quantities of myristic, arachidic, and linolenic acids are also reported. One sample of oil having unusually good stability was found to contain 0.04% tocopherol (Eckey, 738-39 ; Jordan *et al.*, 237, 70).

Analysis of 16 samples of oil from tobacco seeds grown in different parts of India showed the following ranges of values: acid val., 1.1-1.7 ; sap. val., 187.2-193.0 ; and iod. val., 134.5-142.4 ; linoleic acid, 62.0-70.0 ; and linolenic acid, 1.1-2.4%. Another examination of oil samples (iod. val., 129.7-140.2) from various parts of the country showed the following fatty acid composition: saturated, 12.8-19.5 ; oleic, 9.3-19.3 ; linoleic, 63.6-72.6 ; and linolenic, 1.1-2.0%. In general, the Indian tobacco seed oil contains over 66% polyethenoid acids and is, therefore, suited for the paint industry. The unusually low iodine value (112.2) and linoleic acid content (54.6%) that has been reported for an oil from Guntur, and also for some substandard commercial samples may be due either to adulteration of the seed or the oil, or collection of the seeds before they are fully ripened ; oils from unripe seeds are known to be less unsaturated (Kapadia & Aggarwal, loc. cit. ; Chakraborty & Chakrabarty, *Sci. & Cult.*, 1954-55, **20**, 555 ; Venkata Rao *et al.*, *J. Indian chem. Soc.*, 1943, **20**, 374).

The component glycerides of a commercial sample of oil from India (iod. val., 140.7 : fatty acid composition : palmitic 7.0, stearic 2.9, arachidic 0.8, oleic 17.2, linoleic 70.9, and linolenic 1.2% mol.) were as follows: disaturated-linoleins, 3 ; saturated-oleo-linoleins, 3.3 ; saturated-linoleo-linoleins, 0.3 ; saturated-dilinoleins, 22.5 ; oleo-dilinoleins, 48.2 ; linoleno-dilinoleins, 3.4 ; and trilinolein, 19.3% mol. (Crawford & Hilditch, *J. Sci. Fd Agric.*, 1950, **1**, 230).

Uses—Refined tobacco seed oil has been used as an edible oil in a number of European countries without causing any ill effects. It has been found to be suitable for the production of *vanaspati* and has the advantage of being cheaper than groundnut oil. It is sometimes employed as an adulterant of groundnut oil in South India though its presence is reported to cause biliousness. The oil is a good illuminant, burning steadily with a smokeless flame. Hydro-

generated oil can serve as a cheap raw material for soap making (Mahant & Pandit, *J. sci. industr. Res.*, 1948, **7A**, 229 ; Rao & Ramanayya, *ibid.*, 1948, **7B**, 87 ; Chakrabarty & Chakrabarty, *ibid.*, 1959, **18A**, 530).

Tobacco seed oil is being increasingly used in the paint and varnish industry. It is employed after suitable modification or blending with such drying oils as linseed, tung and dehydrated castor. It has fair drying properties : alone it dries more slowly than linseed oil but with driers its drying rate is about the same as boiled linseed oil. The films obtained from double-boiled tobacco seed oil have better lustre and greater flexibility than double-boiled linseed oil, but they get tacky on standing. Blown tobacco seed oil resembles blown linseed oil ; tobacco seed stand oil can replace polymerized linseed oil with advantage in certain varnishes. Isomerized tobacco seed oils, with quick drying properties, have been obtained by heating the raw oil in the presence of certain catalysts. They give films which do not develop tackiness and are superior to the films prepared from linseed oil in that they do not blush when immersed in water, do not turn yellow on ageing, and have greater flexibility and durability. The modified tobacco seed oils are suitable for the preparation of ready mixed paints and varnishes, as such or in admixture with linseed or dehydrated castor oil (Jordan *et al.*, 70, 237 ; Rao & Ramanayya, *loc. cit.* ; Sharma *et al.*, *J. sci. industr. Res.*, 1951, **10B**, 33 ; 1952, **11A**, 109).

The fatty acids from tobacco seed oil can completely replace linseed oil fatty acids in the preparation of alkyd resins, which develop good wrinkle patterns on baking and can be applied to metal, glass, cloth, paper and rubber surfaces. Isomerized tobacco seed oil, constituting 70-80% of the blend with Kamala seed oil or tung oil, is suitable for the production of air drying wrinkle finishes. Salts of the polymerized acids from the oil have been found to be superior to ester gum and zinc rosinates as varnish resins. Tobacco seed oil also gives good factice for use in rubber industry. Optimum conditions have been worked out for obtaining a sulphated oil for the leather industry ; it formed a whitish creamy emulsion with water and gave satisfactory results for fat-liquoring semi-chrome suedes [Kapur & Sarin, *J. sci. industr. Res.*, 1951, **10B**, 94, 168 ; Sharma & Aggarwal, *Paintindia*, 1951-52, **1**(11), 34 ; Sethi & Aggarwal, *J. sci. industr. Res.*, 1951, **10B**, 205 ; Rao & Raghu-nath, *ibid.*, 1955, **14B**, 425 ; Kishore, *Bull. cent. Leath. Res. Inst., Madras*, 1955-56, **2**, 329].

Seed cake—The seed cake obtained after extraction of the oil serves as a protein-rich feed for cattle and horses. It is similar to gingelly seed cake in composition. Analysis of the cold-drawn cake from Coimbatore gave the following values (dry basis) : crude protein, 30.58 ; true protein, 28.52 ; ether extr., 16.00 ; crude fibre, 16.60 ; carbohydrates, 26.53 ; and ash, 10.29%. Feeding trials have shown that the tobacco seed cake is readily eaten by animals without any ill effects. The seed meal protein is deficient in lysine and can be ameliorated by the addition of casein, skimmed milk powder or lysine. The processed seed meal, after removal of the fat with solvent and enriching with lysine-rich proteins, can serve as a source of protein for human consumption. The high protein content of seed meal makes it a potential source of raw material for the plastics industry (Rao & Narasimham, *loc. cit.* ; Kuppuswamy *et al.*, 83 ; *Nutr. Abstr. Rev.*, 1946-47, **16**, 881 ; Mahant & Pandit, *loc. cit.*).

The seed cake can be used as a good nitrogenous manure. It resembles castor cake in manurial value and contains : nitrogen, 4.89 ; phosphorus (P_2O_5), 1.85 ; potash (K_2O), 1.13 ; and lime (CaO), 0.65% (Rao & Narasimham, *loc. cit.*).

MARKETING AND TRADE

About four-fifths of the Indian crop is stated to be sold by the tobacco growers in their villages. The standing crop may be sold as in the Nipani area, but the more common practice is to sell the leaf after curing it in the village. The system of selling the green leaf after harvesting to professional curers is adopted to some extent for Virginia types in Guntur ; in Mysore all the Virginia crop and a large part of the indigenous crop is sold in this way (*Agric. Marketing India, Rep. Marketing Tobacco, Marketing Ser.*, No. 76, 1953, 130-42 ; *Indian Tob. Monogr.*, 363-70).

The grower or the curer, as the case may be, roughly sorts the flue cured Virginia tobacco into seven or eight grades, packs it into *kutcha* bundles covered with gunny and takes them on bullock carts to the purchase depot. About 80 per cent of the tobacco crop in the Guntur-Godavari belt is said to be sold by the growers or curers in about 67 purchase depots established by large leaf handling concerns. In the depot each bundle is opened and examined and the grade is fixed and a price offered per candy of 500 lb. (c. 227 kg.) (*Rep. Marketing Tobacco*, 1953, 135-37 ; *Indian Tob. Monogr.*, 367-69).

Some of the important assembling and distributing centres for tobacco in different States are: Chikodra, Nadiad, Petlad, Mogri and Anand in the Charotar area of Gujarat ; Nipani, Sangli and Jayasingpur in the Nipani area in Mysore and Maharashtra : Gulbarga, Raichur, Ravandur and Sira in Mysore State ; Guntur, Kovvur, Rajahmundry, Vijayawada, Mangalgiri, Chilakaluripet, Parchoor, Vetapalam, Ongole, Tadikonda, Warangal, Samalkot and Kakinada in Andhra Pradesh : Coimbatore, Gudiyattam, Erode, Tiruchirapalli and Madurai in Madras ; Cooch Behar, Jalpaiguri and Calcutta in West Bengal : Muzaffarpur, Darbhanga, Dalsingsarai, Khajauli, Barh, Shahapur-Patoree and Patna in Bihar ; Farrukhabad, Varanasi, Lucknow, Biswan, Mainpuri, Budaun, Kampil, Meerut, Bahraich and Moradabad in Uttar Pradesh (*Rep. Marketing Tobacco*, 1953, 150-52).

Grading—The growers do not generally separate the leaves of different sizes and qualities but bundle them together for sale to merchants who sort them into some rough grades according to the requirements of trade. The exporters who buy such leaves, grade them again according to Agmark specifications prescribed under the Tobacco Grading and Marketing Rules, 1937. Many big manufacturers prefer to visit or send representatives to areas of fairly uniform tobacco production and buy leaves in bulk at flat rates and grade them subsequently to suit their requirement (*Indian Tob. Monogr.*, 370).

A scheme of voluntary grading and marking of tobacco meant for export was introduced first in 1937 but it did not operate successfully. Special legislation was sponsored in 1945 to control the quality of exports : the export of flue cured Virginia tobacco and a few other types was prohibited unless it was

graded and marked in accordance with rules framed for the purpose. A special inspecting and grading staff has been appointed to watch all operations from grading, stemming and redrying to the actual packing of tobacco. Agmark labels in duplicate, indicating the type and grade designation, are required to be placed, one inside the package and the other on the outside, to enable every individual package to be traced right back to its origin. Standard samples of different grades are prepared from the average run of the crop at the beginning of each season for purposes of reference and samples are also sent overseas to embassies and trade representatives of the Government of India. Following these steps there has been a steady rise in the quantity of tobacco graded for export (Table 17) (*Indian Tob. Monogr.*, 379 80, 391-94 : *Rep. Marketing Tobacco*, 1953, 166-72).

Agmark specifications have been framed for ten commercial types of tobacco, of which flue cured Virginia is by far the most important. The most important elements determining quality in this type are colour, texture, size, extent of blemish, strength, even burning with white ash and agreeable flavour. For export and for agmarking the leaf is classified into 20 grades based largely on colour, texture and the amount of blemish on the leaf surface ; the size of the leaf or its position on the plant are not taken into account at present in sorting. Besides flue cured tobacco the other important commercial types for which grade specifications have been laid down are : sun cured *Natu*, sun cured Virginia, sun cured *Jati* and *White Burley* among *N. tabacum* and sun cured *Motihari* among *N. rustica* types (*Indian Tob. Monogr.*, 371, 381-85).

The quality characteristics desirable in cigar tobaccos are uniform brown colour, thin to medium

TABLE 17—QUANTITY AND VALUE OF TOBACCO GRADED*

	Qty (in thousand kg.)					Val. (in thousand Rs.)				
	1958	1959	1960	1961	1962	1958	1959	1960	1961	1962
Flue cured Virginia	48,276	37,434	40,795	45,507	61,094	134,998	124,955	125,169	129,455	189,004
Sun cured Virginia	1,237	1,294	876	1,018	2,210	1,126	969	904	1,304	2,785
Sun cured <i>Natu</i>	1,774	1,741	1,999	2,613**	4,769†	3,982	4,085	4,043	7,118**	13,236†
Sun cured <i>White Burley</i>	526	336	637	576	498	778	805	1,549	1,581	1,580
Sun cured <i>Motihari</i>	47	35	25	35	43	164	126	112	169	152
Others	23	75	81	184	787	7	26	24	81	575
TOTAL	51,883	40,915	44,413	49,933	69,401	141,055	130,966	131,801	139,708	207,332

* *Tob. Bull.*, 1959, 9(1), 15 ; 1960, 10(1), 18 ; 1962, 12(1), 16 ; 1963, 13(1), 16.

** Includes 357 thousand kg. of sun cured *Natu* bidi tobacco flakes of a value of 1,282 thousand rupees.

† Includes 1,122 thousand kg. of sun cured *Natu* bidi tobacco flakes of a value of 4,525 thousand rupees.

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and pliable texture, good size, mild strength, good burning with white ash and agreeable flavour. For wrapper, the leaf should be pliable, smooth and long ; for binder, size is relatively less important and in the case of filler, body and aroma are more important. No particular system of grading is practised for cigar tobacco in this country and the manufacturers sort the leaf in accordance with their requirements. For cheroots, a leaf with dark brown colour, medium thickness, medium to strong flavour, even burning quality and white ash is preferred. Agmark specifications have been prescribed for sun cured *Jati* and *Jati Bishpath* tobacco used in cheroot making (Indian Tob. Monogr., 373, 388).

In the case of bidi leaf, a strong and agreeable smoke is said to be the most important factor, followed by colour and thickness. The leaf should be thick but not coarse and its colour should be orange to light greenish brown with the characteristic brown spots. No systematic grading is done either in Charotar or Nipani, the main bidi tobacco areas, but leaves from the main crop, the ratoon crop and sand leaves are said to be cured, crushed and sold separately. Recent studies on the quality factors of bidi tobacco are reported to have shown that there was a gradient in these factors from the lower to the upper leaves, the latter being heavier in weight and developing the desirable parrot green colour and spangling more extensively than the lower leaves. The grouping of the ten leaves excluding the sand leaves into an upper five and a lower five is said to offer a practical method of grading this tobacco. The bidi leaf grown in Mysore areas is said to be sorted according to size and position of the leaves on the plant into three sorts (Indian Tob. Monogr., 373-74).

For hookah tobacco, a thick coarse leaf strong in flavour is desired and other factors like colour and size of leaf are considered relatively unimportant. It is not generally graded but the *Desi* tobacco of North Bihar area is sorted in accordance with the position of the leaf on the plant. For chewing in the leaf form, a medium texture is preferred but a thick leaf with absorbing capacity is said to be desired for manufactured chewing tobacco and the extent of white incrustation on the surface of the cured leaf is considered an indication of quality in Mysore and parts of Madras. For making snuff, the leaf should be brown to dark brown in colour and thick to brittle so that it can be crumbled into powder (Indian Tob. Monogr., 374-76).

Redrying—After grading, the bright grades of the flue cured Virginia and certain grades of sun cured Virginia and sun cured *Natu* are "stemmed" or stripped by removing by hand or by a U-shaped knife the midrib up to $\frac{1}{2}$ - $\frac{3}{4}$ of its length. The bulk of tobacco exports to U.K. consists of stripped tobacco. The graded and stemmed (and sometimes even unstemmed) leaf is reconditioned or redried. The redrying plant consists of three distinct sections in the first of which the tobacco is dried at 160°-180°F. when the leaf becomes more or less dry containing 6-8% moisture. The leaf is then cooled to 100°F. in the cooler from where it passes into the orderer where steam at low pressure and water in the form of fine spray are injected to form a mist and the leaf absorbs the moisture to the required extent, i.e. generally 10.5-11.5% (Rep. Marketing Tobacco, 1953, 121-22; Garner, 424-26).

The cured and fermented leaf is generally packed for transport into bundles, bags, bales or cases of varying sizes and capacity. The leaves are usually spread out and tied into small bundles and the bundles in turn tied or packed together to form large packages weighing from 35 to 180 kg. or sometimes up to 350 kg. The bidi tobacco powder is packed in the Charotar and Nipani areas in gunny bags in two sizes, the smaller ones with a capacity of about 45-55 kg. and the larger ones of about 90 kg. The cured leaves of the hookah tobacco in Uttar Pradesh and Punjab are twisted into ropes each weighing 9-10 kg. The redried tobacco exported from the Guntur-Godavari area is packed in bales, cases or hogsheads. The top grades of cigarette tobacco exported are packed in cases of 181 kg. made of Punjab firewood. Waterproof paper and matting or double waterproof paper are used for the bales which are finally covered with gunny cloth (Rep. Marketing Tobacco, 1953, 123-25).

Storage—The storage of tobacco has an important bearing on its smoking quality. The cured and graded leaf of cigarette tobacco undergoes fermentation when kept in store for more than 24 months and loses its rawness and harshness and becomes mellow with an agreeable aroma. Bidi and hookah tobaccos also improve in quality after storage for 6-12 months. Unmanufactured tobacco is stored under licence in private bonded warehouses or store rooms by merchants and commission agents in the principal markets. The store rooms and warehouses range from buildings with thatched roofs and mud floors to well-built structures with paved floors and

roofs of corrugated iron or asbestos sheets. The leaf is stored in bags, bundles or bales, on platforms of wooden planks or bricks. The larger cigarette factories store their leaf supplies in air-conditioned rooms with a temperature range of 60°–70°F. and relative humidity 65–70%. The leaf is commonly kept in bales, though it is believed that it matures better when packed in hogsheads and cases. There are Government bonded warehouses at the principal ports importing tobacco from abroad like Madras, Bombay and Calcutta and also in Kakinada port from where tobacco from the Virginia tobacco growing areas in Guntur and Godavari districts is exported (*Rep. Marketing Tobacco*, 1953, 177–84).

Considerable losses are incurred during storage of

tobacco due to deterioration in quality as well as shrinkage in weight by loss of moisture and insect attack. Overmoist and overpressed tobacco deteriorates faster and is subject more readily to deterioration of colour. Immature leaves yielding green grades are more susceptible to insect attack than tobacco of other grades. There is no deterioration in quality in the case of redried leaf during storage and only a very small loss in weight of about 1–1½ per cent takes place when the leaf is packed in hogsheads or wooden cases and stored in air-conditioned rooms for 1–2 years (*Rep. Marketing Tobacco*, 1953, 186–88).

Exports—Though tobacco occupies annually only about 0.35% of the total crop area in the country, it is important commercially as an export commodity and earns an excise revenue of nearly 500–700 million rupees annually. As a producer of tobacco India ranks third, but as an exporter it holds the fifth position among the tobacco exporting countries, the first four being U.S.A., the Federation of Rhodesia & Nyasaland, Turkey and Greece (Table 18). The low percentage of India's export in relation to her production is said to be due to the fact that a large proportion of the total production consists of indigenous types mostly utilized for cigar, cheroot and bidi manufacture and for hookah and chewing purposes. The exports consist mostly of unmanufactured tobacco (c. 96% by quantity and 93% by value for the period 1958–62), flue cured Virginia tobacco used in the manufacture of cigarettes forming the major part (c. 78% by quantity and 86% by value of the exports) of unmanufactured tobacco for the period 1958–62 (Table 19). The most important market for

TABLE 18—EXPORTS OF UNMANUFACTURED TOBACCO FROM SOME IMPORTANT PRODUCING COUNTRIES

	Qty (in thousand kg.)				
	1958*	1959*	1960*	1961**	1962**
U.S.A.	218,765	211,201	224,606	227,180	212,682
Rhodesia & Nyasaland	64,989	79,847	87,237	95,251	98,013
Greece	62,371	55,987	60,308	65,710	45,674
Turkey	56,086	66,793	57,916	88,424	90,686
India	48,089	37,261	41,068	48,057	63,397
Brazil	30,060	28,050	30,935	48,723	n.a.
Cuba	25,987	26,363	27,781	20,412	n.a.
Indonesia	21,396	15,464	24,000	17,545	n.a.
Yugoslavia	23,177	16,156	18,144	15,899	15,539
Canada	13,427	18,465	16,873	17,268	22,056

* *Tob. Bull.*, 1961, 11(3), 13; ** Data from the Secretary, Indian cent. Tob. Comm.; n.a.—not available.

TABLE 19—EXPORTS OF UNMANUFACTURED TOBACCO

	Qty (in thousand kg.)					Val. (in thousand Rs.)				
	1958	1959	1960	1961	1962	1958	1959	1960	1961	1962
For the manufacture of:										
Bidis	54	31	50	55	33	135	110	110	199	177
Chewing tobacco	2,576	3,576	3,486	3,921	2,995	3,581	5,100	4,580	5,427	3,757
Cigarettes (Natu) Desi, sun cured	1,157	812	1,340	795	3,280	3,075	2,144	2,360	1,564	6,945
Cigarettes, Virginia flue cured	40,999	30,230	28,213	33,162	53,685	135,469	117,473	108,950	113,866	169,772
Cigarettes, Virginia sun cured	1,118	1,527	1,030	1,577	3,157	2,418	2,529	1,660	4,715	5,812
Cigars & Cheroots	148	19	14	27	42	371	94	70	131	170
Hookah tobacco	21	6	14	137	6	75	28	50	675	24
Snuff	..	17	..	..	..	..	9	..	..	..
Tobacco stalks and stems	630	81	..	32	15	112	22	..	16	9
Other tobacco unmanufactured	1,384	1,374	6,367	8,351	184	1,774	1,772	27,490	21,706	115
TOTAL	48,087	37,673	40,514	48,057	63,397	147,010	129,281	145,270	148,299	186,781

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Indian tobacco is U.K., which takes as much as 40% of our exports by quantity and about two-thirds of the total by value (Table 20). The bulk of Indian tobacco exports to U.K. consists of flue cured Virginia tobacco of bright lemon or orange colour ; the latter is preferred in recent years as it is generally better bodied (*Agric. Marketing India, Marketing of Tobacco in India, Marketing Ser.*, No. 123, 1960, 27 ; *Tobacco, Commodity Ser.*, 3, Econ. Division, State Tr. Corp., India, 18).

India is said to be facing keen competition in the U.K. market from U.S.A., the Federation of Rhodesia & Nyasaland and Canada in the export of Virginia leaf. The U.S.S.R. usually ranks second as a buyer of Virginia tobacco from India and is followed by Netherlands, Belgium, the Irish Republic and West Germany. The other countries buying significant quantities of Virginia tobacco from India are Singapore, Malaya, French West Africa and Egypt. The other important kinds of unmanufactured

tobacco exported are tobacco for the manufacture of chewing tobacco mainly to Aden and sun cured Virginia and *Desi* tobaccos to U.K. and some other west European countries for blending with flue cured tobacco, in the manufacture of cigarettes.

The exports of manufactured tobacco consist chiefly of bidis exported mainly to Ceylon and Singapore followed by manufactured hookah and bidi tobaccos mainly to Saudi Arabia and Ceylon, respectively. Small quantities of cigarette, snuff and other kinds of manufactured tobacco are also exported (Table 21).

Imports—The imports of tobacco into India consist chiefly of unmanufactured Virginia flue cured tobacco mainly from U.S.A. for making cigarettes. The value of the imports has shown a steady decline in the postwar years from 46 million rupees in 1947-48 to 14 million rupees in the year 1959 and to 2.3 million rupees in 1960 ; it has, however, gone up again during 1961 and 1962 (Table 22).

TABLE 20—EXPORTS OF TOBACCO FROM INDIA TO SOME IMPORTANT COUNTRIES

	Qty (in thousand kg.)					Val. (in thousand Rs.)				
	1958	1959	1960	1961	1962	1958	1959	1960	1961	1962
<i>Unmanufactured tobacco</i>										
U.K.	19,936	16,305	17,593	25,198	18,001	108,409	87,325	101,353	113,388	102,748
Aden	3,445	4,560	3,808	3,979	3,112	3,907	5,382	4,709	5,328	3,719
U.S.S.R.	3,202	4,442	4,126	5,090	18,070	5,127	7,300	6,270	6,418	38,216
Belgium	1,649	1,762	2,113	2,321	1,596	2,565	3,121	2,995	3,512	3,173
Netherlands	1,472	1,965	1,491	1,879	1,652	2,105	2,821	2,270	2,560	2,821
Egypt	1,226	472	2,236	55	5	2,364	376	3,380	63	6
Hongkong	1,222	1,136	660	377	768	1,355	1,412	827	469	1,225
French W. Africa	1,108	970	1,423	1,776	832	605	547	1,072	1,131	552
Singapore	894	309	1,148	1,359	840	1,090	861	2,972	4,053	2,868
W. Germany	658	549	7	110	20	853	1,074	15	206	18
Irish Rep.	649	1,928	1,701	20	19	3,518	10,883	10,665	35	45
Ceylon	93	179	177	137	109	456	971	974	704	541
Others	12,533*	3,096	4,031	5,756	18,373**	14,656*	7,208	7,768	10,432	30,849**
Total	48,087	37,673	40,514	48,057	63,397	147,010	129,281	145,270	148,299	186,781
<i>Manufactured tobacco</i>										
Ceylon	1,453	1,066	1,015	1,235	1,119	12,968	6,954	7,824	7,354	4,691
Saudi Arabia	306	381	284	394	260	523	676	525	821	574
Singapore	235	163	90	67	37	1,707	1,480	1,034	729	432
Others	134	132	130	241	361	661	648	770	1,528	1,512
Total	2,128	1,742	1,519	1,937	1,777	15,859	9,758	10,153	10,432	7,209

* Includes 10,335,000 kg. of tobacco valued at Rs. 9,131,000 exported to China ; ** includes 5,676,000 kg. of tobacco valued at Rs. 6,063,000 exported to Poland, and 4,372,000 kg. of tobacco valued at Rs. 4,861,000 exported to Yugoslavia.

TABLE 21—EXPORTS OF MANUFACTURED TOBACCO

	Qty (in thousand kg.)					Val. (in thousand Rs.)				
	1958	1959	1960	1961	1962	1958	1959	1960	1961	1962
Cigars & cheroots	2	2	6	3	1	24	13	62	34	5
Cigarettes	77	19	27	34	11	368	135	231	328	129
Bidis	1,379	572	679	490	171	13,696	6,184	7,392	5,556	2,015
Chewing tobacco	3	38	4	23	38	12	94	16	57	57
Hookah or goodaku tobacco	346	442	331	491	491	600	780	611	1,017	1,091
Jarda scented tobacco	2	2	12	3	3	9	17	21	14	18
Snuff	10	14	16	18	15	86	140	145	169	160
Tobacco mixtures for pipes & cigarettes	83	32	a	..	..	366	139	a	..	..
Bidi tobacco	199	604	445	875	1,046	576	2,162	1,672	3,257	3,732
Other tobaccos manufactured	27	17	a	..	1	122	94	2	..	2
TOTAL	2,128	1,742	1,519	1,937	1,777	15,859	9,758	10,153	10,432	7,209

a--below 500.

TABLE 22—IMPORTS OF TOBACCO

	Qty (in thousand kg.)					Val. (in thousand Rs.)				
	1958	1959	1960	1961	1962	1958	1959	1960	1961	1962
<i>Unmanufactured</i>										
U.S.A.	1,344	1,227	238	728	1,076	13,616	13,090	2,318	8,088	12,735
Others	a	284	2	173	a	5	672	9	761	2
TOTAL	1,344	1,511	240	901	1,076	13,621	13,762	2,327	8,849	12,737
<i>Manufactured</i>										
U.K.	12	2	5	7	3	297	87	122	163	105
Others	2	1	2	105	6	38	27	44	1,142	133
TOTAL	14	3	7	112	9	335	114	166	1,305	238

a--below 500.

Excise duty—Tobacco has been subject to excise duty from 1943 and the amount collected by way of tobacco excise forms a sizeable proportion of Central revenues. The duty is levied on tobacco in its unmanufactured or cured form and also on some of its manufactured products. A system of licensing is adopted whereby curers, brokers, commission agents, wholesale dealers, warehouse owners, manufacturers and exporters are all expected to obtain prior licence from Central Revenue authorities. But the tax itself is collected at a point as near as possible to consumption. Only that part of the tobacco produced in the

country which goes into internal consumption is taxed : no duty is levied on unmanufactured tobacco exported outside India nor on stem dust and other tobacco used in the country for purposes other than human consumption. The rates of duty, which are more or less related to the principle of ability to pay, range (as on 1-3-1963) in the case of unmanufactured tobacco from Rs. 21.38 (inclusive of basic, additional and special duties) per kg. if it is flue cured and used for the manufacture of smoking mixtures for pipes and cigarettes to Rs. 0.28 per kg. on stalks: on excise is levied on tobacco used for agricultural purposes.

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TABLE 23—EXCISE REVENUE FROM TOBACCO

Year	Revenue (in million Rs.)
1943-44	97
1944-45	173
1945-46	208
1946-47	189
1947-48	187
1948-49	253
1949-50	259
1950-51	295
1951-52	355
1952-53	340
1953-54	332
1954-55	319
1955-56	364
1956-57	380
1957-58	458
1958-59	509
1959-60	544
1960-61*	594
1961-62*	632
1962-63*	730

Indian Tob. Statist., Indian cent. Tob. Comm., 1960, 169.
* *Tob. Bull.*, 1961, 11(4), 3; 1962, 12(2), 3; 1963, 13(2), 38.

The annual revenue derived by way of tobacco excise duties during 1943-63 is given in Table 23. Details regarding the respective shares of revenue realized from the various categories of raw and manufactured tobaccos during 1956-62 are given in Table 24 [*Indian Tob.*, 1952, 2, 59; *Indian Tob. Monogr.*, 11; *Tob. Bull.*, 1963, 13(2), 69].

A small agricultural cess on tobacco exported and a grading cess on bales of tobacco graded for export are also levied, the former being made over for research work and the latter to the funds of the Tobacco Grading Scheme. Import duty at varying rates is collected on all tobaccos imported into India (*Indian Tob. Monogr.*, 12).

Tobacco seed and seed oil—Tobacco seed can be harvested for extraction of the seed oil but the production of seed for this purpose is restricted to Virginia tobacco where the plants are not topped. The yield of seed is estimated at about 196 kg. per hectare and the production of seed and its oil is mainly confined to Andhra Pradesh where the cultivation of

TABLE 25—PRODUCTION OF TOBACCO SEED AND OIL*

(in thousand kg.)

	1958-59	1959-60	1960-61	1961-62	1962-63**
Tobacco seed collected for extraction of oil			6,613	5,050	4,158
Tobacco seed oil produced			1,541	1,212	1,039
			6,613	5,050	4,568
					6,530
					1,136
					1,698

* Data from the Secretary, Indian cent. Tob. Comin.

** Data from the Director of Agric., Andhra Pradesh.

TABLE 24—EXCISE REVENUE REALIZED ON RAW AND MANUFACTURED TOBACCO (TYPEWISE)

(in million Rs.)

Year	Revenue from raw tobacco intended for the manufacture of						Total	Revenue from manufactured tobacco		Total excise revenue
	Bidis	Cigarettes	Chewing tobacco	Hookah tobacco	Cigars & Cheroots	Other products & miscellaneous duties		Cigarettes	Cigars & Cheroots	
1956-57	109	57	46	45	16	8	281	97	2	380
1957-58	138	65	56	46	21	20	346	111	1	458
1958-59	135	70	62	45	22	44	378	130	1	509
1959-60	131	76	61	45	21	54	388	155	1	544
1960-61	143	87	64	45	21	56	416	177	1	594
1961-62	146	100	70	49	22	50	437	194	1	632

TABLE 26—EXPORTS OF TOBACCO SEED OIL FROM INDIA
(Qty in thousand kg. and val. in thousand Rs.)

	Qty				Val.		
	1960-61	1961	62	1962-63	1960-61	1961-62	1962
U.K.	790	327	552	1,173	567	519	
France	..	..	11	..	..	18	
TOTAL	790	327	563	1,173	567	537	

Virginia tobacco is concentrated. Table 25 gives the quantity of seed collected for crushing and oil produced during the period 1958/59-1962/63. Major portion of the oil is exported to U.K. (Table 26).

NIGELLA Linn. (*Ranunculaceae*)

A small genus of annual herbs found in southern Europe and western Asia, but chiefly in the Mediterranean region. Three species are recorded in India.

N. damascena Linn. LOVE IN A MIST

Bailey, 1947, II, 2146, Fig. 2482.

A glabrous, erect annual, 30-50 cm. high, often cultivated in Indian gardens for its pretty flowers and feathery foliage. Leaves bright green, finely cut; flowers white or light blue, large, with a dense finely cut involucle; capsules globular-oblong, inflated; seeds black, transversely ribbed.

The seeds of this plant emit an aroma resembling that of strawberries when crushed. On steam-distillation they yield from 0.4 to 0.5% of a yellow volatile oil (Nigella Oil) exhibiting a blue fluorescence. The oil has an agreeable odour and taste and the following characteristics: d^{15}_4 , 0.895-0.915; n^{20} , 1.4997-1.5582; $[\alpha]_D$, +1.06° to -7.8°; acid val., 1.1; ester val., 14.0; ester val. after acetylation, 17.7; soluble in abs. alcohol in all proportions but not completely soluble in 90% alcohol. The chief constituent of the oil is the alkaloid damascenine (3-methoxy-N-methyl-anthranilic acid methyl ester, $C_{10}H_{13}O_3N$, m.p. 24-26°, b.p. 270°/750 mm.); it is present in a concentration of c. 9% and the fluorescence of the oil is due to it. It is reported to be used in perfume specialities. Nigella oil is not produced on a commercial scale (Poucher, I, 302; Gildemeister & Hoffmann, IV, 611; Guenther, VI, 165; II, 654-55).

The seeds on extraction with petroleum ether yield 43.5% of a semi-drying oil which may find use in soap making. The oil is yellowish brown in colour, with an aromatic odour and a blue violet fluorescence. It has the following characteristics: sp. gr.²², 0.919; n^{20} , 1.476; acid val., 59.7; ester val., 133.3; iod. val., 116.18; R.M. val., 2.50; Polenske val., 0.35; and unsapon. matter, 1.88%. The seeds contain a highly active lipase which is possibly responsible for the unusually high acid value of the oil. They contain also a toxic saponin, melanthine, in traces (Vishin, *Curr. Sci.*, 1961, 30, 55; *Chem. Abstr.*, 1943, 37, 6004; Wehmer, I, 312).

The seeds of *N. damascena* were formerly used as a household remedy in the Mediterranean region. They are said to be effective as carminative, emmenagogue and anthelmintic. In homeopathy, a tincture prepared from the ripe seeds is used against catarrhal inflammations of liver and intestines (Vishin, loc. cit.).

N. sativa Linn. SMALL FENNEL, BLACK CUMIN

D.E.P., V, 428; C.P., 811; Kirt. & Basu, I, 11.

HINDI.—Kalonji, kalajira, mugrela; BENG.—Kali-jira, mungrela; GUJ.—Kalonji-jiram; TEL.—Nella-jeelakaira; TAM.—Karunjiragam; KAN.—Karejirage; MAL.—Karunchiragam.

A small herb, c. 45 cm. high, native of Levant, said to be cultivated or occasionally found as a weed of cultivation in Punjab, Himachal Pradesh, Bihar and Assam. Leaves 2-3 pinnatisect, 2.5-5.0 cm. long, cut into linear-lanceolate segments; flowers pale blue, 2.0-2.5 cm. across, without an involucre, on solitary long peduncles; seeds trigonous, black, rugulose-tubercular.

Data relating to the cultivation of *N. sativa* in India are not available. It is not probably cultivated on any considerable scale; seeds are collected mostly from plants growing wild in forest areas for use as flavouring material and for medicinal purposes.

Analysis of black cumin gave the following values: total ash, 3.8-5.3; ash insol. in HCl, 0.0-0.5; volatile oil, 0.5-1.6; ether extr. (fatty oil), 35.6-41.6; and alcoholic acidity (as oleic acid), 3.4-6.3%. The seeds give on steam-distillation a yellowish brown volatile oil with an unpleasant odour. It has the following characteristics: d^{15}_4 , 0.875-0.886; n^{20}_D , 1.4836-1.4844; $[\alpha]_D$, +1.43° to +2.86°; acid val. up to 1.9; ester val., 1-31.6; ester val. after acetylation, 15-73; sol. in 2-4.5 or more volumes of 90% alcohol. The oil

NIGELLA

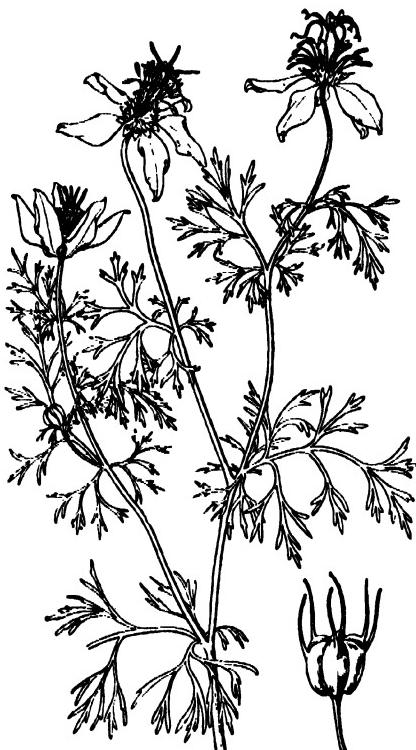


FIG. 21—NIGELLA SATIVA—FLOWERING BRANCH & FRUIT

contains carvone (4.5–60%), *d*-limonene and cymene. A carbonyl compound, nigellone ($C_{18}H_{22}O_4$, m.p. 195–97°), which protects guinea-pigs against histamine induced bronchospasm, has been isolated from the oil. Preliminary clinical trials indicate its possible therapeutic use in some conditions of cough and bronchial asthma (Dutta, *J. Instn Chem. India*, 1959, **31**, 295; Gildemeister & Hoffmann, IV, 611; Nadkarni, I, 855; Mahfouz & El-Dakhakhny, *J. pharm. Sci. U.A.R.*, 1960, **1**, 9).

The fatty oil obtained by the expression of seeds is reported to be used for edible purposes. Extraction with benzene and subsequent steam-distillation of extract to remove the volatile oil gave c. 31% of a reddish brown, semi-drying oil with the following characteristics: sp. gr.^{20/40}, 0.9152; n^{21} , 1.4662; acid val., 42.83; sap. val., 199.6; iod. val., 117.6; acet. val., 24.1; Hehner val., 89.6; R.M. val., 3.9; and unsapon. matter, 0.03%. The fatty acids of the oil are as follows: myristic, 0.26; palmitic, 6.31; stearic, 2.45; oleic, 44.45; and linoleic, 35.99%. The component glycerides of the oil are the following: trilinolein, 2; oleodolinolein, 25; dioleolinolein, 42; palmito-oleolinolein (containing small amount of myristic acid),

24; and stearo-oleolinolein, 7%; glycerides of some volatile acids are also present in the oil in small quantities (Eckey, 400; Kartar Singh & Tiwari, *Proc. nat. Acad. Sci. India*, 1942, **12A**, 141; 1943, **13A**, 54).

Besides the volatile and fatty oils, black cumin seeds contain a bitter principle (nigellin), tannins, resins, proteins, reducing sugars (mostly glucose), saponins and arabic acids and other alcohol-soluble organic acids. The free amino acids present in dormant seeds are cystine, lysine, aspartic acid, glutamic acid, alanine, tryptophan, valine and leucine; asparagine is not present. An amorphous saponin ($C_{20}H_{32}O_7$, m.p. 310°) which on hydrolysis yields a yellow phenol ($C_{11}H_{22}O_2$, m.p. 275°) and glucose, and a toxic saponin, melanthin, which gives on hydrolysis melanthigenin ($C_{30}H_{48}O_6$, m.p. above 325°, probably identical with hederagenin) are also identified. The concentration of alcohol-soluble acids in broken or powdered seeds increases rapidly during storage even in closed containers. A lipase is present in the seeds. Leaves contain ascorbic acid (257.70 mg./100 g.) and dehydroascorbic acid (29.5 mg./100 g.) (Hoppe, 604; *Biol. Abstr.*, 1950, **24**, 2030; Dutta, loc. cit.; *Chem. Abstr.*, 1954, **48**, 233; 1947, **41**, 6672; 1943, **37**, 3441, 6004; 1953, **47**, 12537; Wehmer, I, 313).

The seeds of *N. sativa* are considered carminative, stimulant, diuretic, emmenagogue, galactagogue, and are used in the treatment of mild cases of puerperal fever. They are externally applied for eruptions of skin. Alcoholic extracts of the seeds show antibacterial activity against *Micrococcus pyogenes* var. *aureus* and *Escherichia coli*. They can be used as a

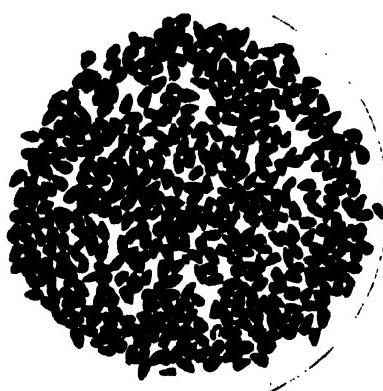


FIG. 22—NIGELLA SATIVA—SEEDS

stabilizing agent for edible fats. Seeds are scattered between folds of linen or woollen clothes to preserve them against insect attack (Kirt. & Basu, I, 12 ; Koman, 1919, 18 ; Kurup, *J. sci. industr. Res.*, 1956, 15C, 153 : Sethi & Aggarwal, *ibid.*, 1952, 11B, 468 ; Chopra *et al.*, 131).

Bazaar samples of seeds are often adulterated. According to the Prevention of Food Adulteration Rules, black cumin must conform to the following standards: foreign organic matter, $\geq 5\%$; total ash, $\geq 7\%$; ash insol. in HCl, $\geq 1.25\%$; and volatile oil, $\leq 0.5\%$. Black cumin should be supplied whole and not in broken or powder form and the total alcohol-soluble acids should not exceed 6.5% (Dutta, loc. cit.).

Niger — *see* **Guizotia**

Night Jasmine — *see* **Nyctanthes**

Night Jessamine — *see* **Cestrum**

Nightshade — *see* **Solanum**

Nightshade, Deadly — *see* **Atropa**

Nilgai — *see* **Gazelles, Antelopes & Goat-Antelopes**

Nilgiri Nettle — *see* **Girardinia**

Nilgiri Strawberry — *see* **Fragaria**

Niobium — *see* **Tantalum Ores**

Nipa Palm — *see* **Nypa**

NITRE

D.E.P., VI (2), 431 ; C.P., 972.

HINDI & GUJ.—*Shora, suriakhar* ; BENG.—*Sora* ; TEL & KAN.—*Petluppu* ; TAMIL.—*Pottiluppu*.

Nitre (KNO_3 ; sp. gr., 2.109 : H., 2), also known as Saltpetre, is nitrate of potassium crystallizing in the orthorhombic system generally in thin crusts and silky tufts. It sometimes occurs in massive, granular, or earthy forms. The mineral is colourless to white and brittle with a vitreous lustre. Refined nitre, besides being an important constituent of gun powder, finds use in the manufacture of glass, and for food preservation and manurial purposes.

Nitrate is commonly found as a surface efflorescence on soils rich in organic matter. It may occur in small amounts on old walls, porous rocks, and in caves and other sheltered places. The mineral is formed in soils when nitrogenous organic substances decay in contact with potassium salts, the reaction

being brought about by nitrifying bacteria. The climate best suited for its formation is where hot dry weather follows the rains and thus by evaporation induces the salt to effloresce on the surface. As the nitrate is soluble in water, the occurrences containing the mineral in commercially workable quantities are uncommon. The mineral is also found in association with soda nitre deposits in the arid regions of Chile and elsewhere.

Nitre is produced from the soil from old village sites in India, and in small amounts in Turkey, Spain, Peru, Guatemala, Mexico, Persia and China. It is also produced in Chile from the vast soda nitre deposits. India had a virtual monopoly of the world's supply of nitre in the past, but was displaced from her leading position due to the production of synthetic potassium nitrate from soda nitre and potassium chloride, and the development of suitable substitutes.

DISTRIBUTION

Nitre occurs as a natural efflorescence over extensive areas in Bihar, U.P., and the Punjab. It is found in certain other States also but to a limited extent.

Andhra Pradesh—The manufacture of crude nitre was once widespread in the districts of Anantapur, Guntur, Kurnool and Nellore, but the present output is insignificant. Rubbish and mudheaps in ancient or deserted village sites have afforded the necessary raw material from which the nitre was extracted (Coggin Brown & Dey, 468 ; Mahadevan, *Bull. nat. Inst. Sci. India*, No. 5, 1955, 55).

Bihar—The conditions favourable to the formation of the mineral are ideally present in North Bihar where several districts are rich in nitre-carths. Bihar at one time produced as much as 22,000 tonnes of refined nitre per annum mainly from the Muzaffarpur, Saran, Champaran and Darbhanga districts and to a small extent from Shahabad, Gaya and Monghyr. The production has fallen considerably in the recent years but efforts are now being made to revive the industry by setting up pilot refineries (Fermor, *Rec. geol. Surv. India*, 1921, 53, 299 ; Coggin Brown & Dey, 468 ; *Chem. Tr. J.*, 1958, 143, 964).

Gujarat—Sizeable quantities of nitre were recovered near certain villages in Limbdi district such as Talavad and Patan, but the industry has declined. Ahmadabad was also reported to be a centre of nitre manufacture.

NITRE

Madras--A small quantity of crude nitre is produced in Coimbatore and Madurai districts from the soil locally known as *Uppu mannu*. The mineral is also collected in several villages near Mohanur and Velur in the Cauvery valley (Salem dist.) (Iyer, *Madras agric. J.*, 1917, 5, 105; Gupta, *Rec. geol. Surv. India*, 1954, 80, 652; Krishnan, *Mem. geol. Surv. India*, 1951, 80, 268).

Maharashtra--Small amount of nitre was collected in Chinchlee and Raibagh (Kolhapur dist.), but at present no production is reported (Jones, *Rec. geol. Surv. India*, 1923, 54, 430).

Mysore--In Raichur and Gulbarga districts nitre is reported to be a thriving village industry (Mahadevan, *Bull. nat. Inst. Sci. India*, No. 5, 1955, 56).

Punjab--Nitrous earth is collected in sizeable quantities in Hissar and Amritsar districts. The industry has maintained a fairly large number of refineries, particularly at Hissar and Hansa. Nitre is also reported to be collected in Patiala, Jhind and Nabha areas (Gupta, loc. cit.; Coggins Brown & Dey, 468).

Uttar Pradesh--Kanpur, Ghazipur, Allahabad and Varanasi are the chief centres of nitre production. The rate of production has been fairly steady with an annual average of over 2,242 tonnes (Gupta, loc. cit.).

MANUFACTURE AND USES

The soils from which nitre is extracted in India vary greatly in composition, and contain 2-13% of nitrates of potassium, calcium and magnesium, 2-14% of sodium chloride and up to c. 6% sodium sulphate. The nitre content of some soils may be as high as 30%, but generally it does not exceed 3-5%. The manufacture of nitre is carried out mostly as a cottage industry in a rather crude manner by lixiviating the soil with water, filtration and fractional crystallization.

The nitre-rich soil is collected by scraping off the surface to a depth of c. 1-2 cm. In Bihar the extraction is carried out in a circular filter bed or pit (diam. c. 135 cm. and depth c. 45 cm.) consisting of mud wall and floor plastered with clay, and having a platform of bamboos and straw c. 10 cm. above the ground. The platform is carefully packed with the nitrous soil and water is poured on the surface. As the water gradually filters through, it carries off in solution potassium nitrate and other soluble salts present in the soil. The percolating liquor, which is collected in an earthen jar, is transferred to an evaporating pan and concentrated by boiling for

TABLE I--COMPOSITION OF THE COMMERCIAL CRUDE NITRES*

	High Grade %	Low Grade %
Potassium nitrate	66.07	26.86
Magnesium nitrate	2.54	12.24
Sodium chloride	21.84	34.80
Sodium sulphate	3.65	11.20
Moisture	5.00	13.50
Insoluble matter	0.90	1.40

* Gupta, *Rec. geol. Surv. India*, 1954, 80, 649.

nearly 7 hours. The liquor is then removed and allowed to cool and crystallize in an earthen vessel. The crystals of crude nitre are drained in baskets and stored in pits. The process of making crude nitre in U.P. and the Punjab is essentially the same; the filter beds in U.P. are oblong instead of circular. Crude nitre of commerce is contaminated with varying proportions of salts of sodium and magnesium, and sometimes calcium. Table I gives the composition of high and low grade nitrates.

The process of refining of crude nitre varies in different factories. But as sodium chloride is the chief impurity (up to 30% or even more) and as its solubility is practically constant, all the processes are based on the varying solubility of potassium nitrate in hot and cold solution. The crude nitre is dissolved in mother liquor from previous operations and the solution is concentrated by boiling in large evaporating pans for about 3 hours; the insoluble matter and undissolved sodium chloride and sodium sulphate, which settle during evaporation as a granular mass known as *sitta*, are removed with a large iron spade. The dark concentrated liquid is then transferred to settling tanks by means of an iron scoop and is allowed to stand for c. 2 hours., the scum is removed and the clear liquid decanted or syphoned into the wooden crystallizing vats. The crystallization is complete in 8-10 days, after which the mother liquor is run off and the crystals washed with water. The yield of refined nitre varies from 37.5 to 57.5% depending upon the quality of crude nitre. The refined nitre of commerce is of variable composition and may contain up to 95% potassium nitrate with some sodium chloride and sulphates of potassium and sodium.

In some refineries *sitta* is washed with water and the washings are mixed with mother liquor for subsequent extraction. *Sitta* is occasionally sold for

TABLE 2—PRODUCTION OF NITRE IN INDIA (1947-53)
(Qty in tonnes and val. in thousand Rs.)

	Bihar		Madras		Punjab		Uttar Pradesh		Total	
	Qty	Val.	Qty	Val.	Qty	Val.	Qty	Val.	Qty	Val.
1947	..	..	19.3	..	3,087.3	..	..	..	4,179.3	..
1948	..	..	1.1	3.7	1,748.2	528.7	1,260.7	599.2	3,019.2	1,131.6
1949	37.6	9.8	1.2	3.4	5,307.9	2,686.1	1,269.8	767.4	6,616.5	3,466.7
1950	248.9	91.9	..	..	4,760.4	2,009.2	1,188.6	755.5	5,585.3	2,856.7
1951	288.6	198.4	39.6	..	4,268.6	2,771.5	758.6	614.2	5,295.4	3,584.1
1952	222.5	173.0	..	..	6,850.0	3,768.0	1,444.6	1,050.0	8,517.1	4,991.0
1953	..	..	..	..	2,332.5	1,215.4	433.4	268.8	2,821.1	1,502.9

preserving hides and dressing leather. Edible salt (sodium chloride) is also recovered from it in some factories (Hooper, *Agric. Ledger*, 1905, No. 3, 26-39; Hutchinson, *Bull. agric. Res. Inst., Pusa*, No. 68, 1917, 2-7; Rao *et al.*, *J. Indian Inst. Sci.* 1923, 6, 195; Gupta, loc. cit.; Johnstone & Johnstone, 431).

Nitre was formerly extensively used in the manufacture of gunpowder. The oxidizing power of potassium nitrate is made use of in the manufacture of matches and in various pyrotechnics. Other uses of nitre include the manufacture of certain types of glass and ceramic glazes, meat curing, pickling and in medicine. In India it is also employed to a limited extent as a filler in soaps, ingredient in freezing mixtures and as a fertilizer in the tea gardens (Kirk & Othmer, XI, 26-27; West, *Rec. geol. Surv. India*, 1952, 82, 425).

PRODUCTION AND TRADE

Table 2 gives the production of refined nitre in India during 1947-53. No output has been recorded since 1954 when it was estimated at 3,000 tonnes. Punjab and U.P. are the chief producing areas.

India imports small amounts of medicinal grade nitre. During 1962-63, about 19 tonnes of nitre valued at Rs. 14,762 were imported, mainly from West Germany.

Large quantities of nitre were used to be exported in the past to U.K., Ceylon and other countries, but the exports have dwindled during recent years. During 1962-63, the exports of nitre amounted to about 8 tonnes valued at Rs. 15,204. Burma and Aden were the chief importing countries.

NOLTEA Reichb. (*Rhamnaceae*)

Chittenden, III, 1375.

A monotypic genus, represented by *N. africana* Reichb. (SOAPBUSH), a native of S. Africa, introduced

into the Nilgiris where it has more or less run wild. It is an evergreen shrub, 3.0-3.6 m. high, with elliptical leaves, white flowers in panicles and spherical fruits. It is grown as an ornamental plant and sometimes for hedging (Fl. Madras, 225; Bailey, 1947, II, 2148).

The plant is saponaceous; the macerated leaves and twigs are used for washing purposes in Africa. A decoction of the leaf or root is used both prophylactically and therapeutically (Bailey, 1947, II, 2148; Watt & Breyer-Brandwijk, 883).

Nopalea — see Opuntia

NOTHOLAENA R. Br. (*Polypodiaceae*)

Chittenden, III, 1380.

A genus of elegant, dwarf ferns distributed in the warm temperate regions of the world. Three species occur in India, and a few exotics are grown in gardens.

N. eckloniana Kuntze, native of S. Africa, is a dwarf, most beautiful fern with 2- or 3-pinnatifid fronds, found growing in Indian gardens. In S. Africa, the leaves are smoked by the Sutos for the relief of colds in the head and chest (Firminger, 261; Watt & Breyer-Brandwijk, 1087).

Nothopanax — see Polyscias

NOTHOPEGIA Blume (*Anacardiaceae*)

D.E.P., V, 430; Fl. Br. Ind., II, 39.

A small genus of trees distributed in India, Ceylon and Borneo. Six species are found in India.

**N. colebrookiana* Blume (MAR.—*Sonemau*; KAN.—*Ambatti*, *ulagera*, *mattigar*; BOMBAY—*Amberi*) is a small tree, c. 4.5 m. in height, with acrid milky

* This species has now been split into four different species, which are, however, not discriminated in their economic uses.

NOTHOPEGIA

juice found in the evergreen forests in the hills of Deccan Peninsula up to an altitude of 1,500 m. Bark brown, flaky; leaves elliptic-oblong; flowers in racemes, small, whitish; drupes turbinate, c. 2.5 cm. in diam., purple.

The tree yields wood of good quality, which is pinkish yellow, smooth, lustrous, hard, strong and heavy (wt., 993–1057 kg./cu.m.). It is reported to be used in Ceylon for posts, props and scaffolding. The fruit is eaten. The pale juice of the bark becomes permanent black on drying and is said to have been used as an invisible ink (Talbot, I, 361; Gamble, 222; Lewis, 128).

NOTHOSAERVA Wight (*Amaranthaceae*)

D.E.P., V, 430; Fl. Br. Ind., IV, 726.

A monotypic genus of annual herbs distributed in tropical Africa and Asia.

N. brachiata Wight (RAJASTHAN—*Dhaua phin-dawri*), an erect annual, 30–60 cm. high, with spreading puberulous branches, is found throughout the



FIG. 23—NOTHOSAERVA BRACHIATA



FIG. 24—NOTONIA GRANDIFLORA—IN FLOWER

plains in India. Leaves membranous, ovate, blunt or short pointed; flowers white, very minute, in dense axillary spikes; fruits minute, oblong, flattened; seeds dark brown, shining.

This plant is used in Merwara as a pot-herb.

NOTONIA DC. (*Compositae*)

A small genus of herbs or undershrubs distributed in the tropics of Asia and Africa. Four species occur in India.

N. grandiflora DC.

D.E.P., V, 430; Fl. Br. Ind., III, 337.

MAR.—*Wander-roti*; TEL.—*Kundalasevityaku*; TAM.—*Mosakathu-thalai*.

BOMBAY—*Gaidar*.

A small, succulent, semi-shrubby perennial, 0.6–1.5 m. high, found in Konkan, western ghats, Deccan and hills of South India ascending up to 1,500 m. Leaves sessile or shortly petioled, obovate, elliptic-lanceolate or sub-orbicular, very fleshy; flowers pale yellow, in corymbose heads.

The plant is said to possess a feebly aperient property. It is used as a cure for pimples. The plant was supposed to be a remedy for hydrophobia though its

efficacy has not been established (Kirt. & Basu, II, 1407-08 ; Burkill, II, 1563).

Nut, Australian or Queensland — see *Macadamia*

Nut, Betel — see *Areca*

Nut, Butter or Souari — see *Caryocar*

Nut, Candle — see *Aleurites*

Nut, Cashew — see *Anacardium*

Nut, Clearing — see *Strychnos*

Nut, Fever — see *Caesalpinia*

Nut, Fox — see *Euryale*

Nut Grass — see *Cyperus*

Nut, Ground — see *Arachis*

Nut, Hazel — see *Corylus*

Nut, Hickory or Pecan — see *Carya*

Nut, Kola — see *Cola*

Nut, Marking — see *Semecarpus*

Nut, Monkey or Pea — see *Arachis*

Nut, Physic or Purging — see *Jatropha*

Nut, Pistachio — see *Pistacia*

Nut, Rush or Tiger — see *Cyperus*

Nut, Singhara — see *Trapa*

Nut, Soap — see *Sapindus*

Nutmeg — see *Myristica*

Nux-vomica — see *Strychnos*

NYCTANTHES Linn. (*Oleaceae*)

A small genus of shrubs or small trees distributed in the Indo-Malayan region. One species occurs in India.

N. arbor-tristis Linn. NIGHT JASMINE, CORAL JASMINE

D.E.P., V, 434 ; I, 432 ; III, 416 ; VI(1), 138 ; Fl. Br. Ind., III, 603.

SANS.—*Parijata, sephalika* ; **HINDI**—*Harsinghar, seoli* ; **BENG.**—*Sephalika, seoli* ; **MAR.**—*Khurasli, parijatak* ; **GUJ.**—*Jayaparvati* ; **TEL.**—*Kapilanagadustu, pagadamalle, parijatamu* ; **TAM.**—*Manjhapu, pavazhamalligai* ; **KAN.**—*Harsing, parijata* ; **MAL.**—*Pavizhamalli, parijatakam* ; **ORIYA**—*Godokodiko, gunjo seyoli, singaroharo*.

MUNDARI—*Saparom, kula marsal, chamgar*.

A hardy large shrub or small tree, up to 10 m. high, with grey or greenish white rough bark. Branchlets quadrangular, strigose ; leaves ovate, acuminate, entire or with a few large distant teeth, rough and scabrous above, densely pubescent beneath ; flowers small, 3-7 in each head, arranged in trichotomous cymes : corolla fragrant, white, 4-8 lobed, with bright orange tubes ; capsules sub-orbicular, compressed, chartaceous, separating into two flat 1-seeded carpels.

N. arbor-tristis is a native of India occurring wild in the sub-Himalayan region, from Chenab to Nepal, up to 1,500 m., and in Chota Nagpur, Rajasthan, Madhya Pradesh and southwards to Godavari. It is cultivated in gardens almost throughout India for its fragrant flowers. In its natural habitat, it grows gregariously and covers dry steep hill sides and rocky grounds. It tolerates moderate shade and is often found as an undergrowth in dry deciduous forests. It is easily propagated by seeds or cuttings ; it coppices readily and is not browsed by goats. It is leafless in April-May. It blooms from August to December ; flowers open towards the evening and drop off early morning. A powdery mildew, *Oidium* sp., sometimes attacks the foliage ; the disease does not cause much damage and may be controlled by dusting the foliage with sulphur [Troup, II, 661 ; Gopalaswamiengar, 282 ; Bentall, 300 ; Ramakrishnan, S. Indian Hort., 1955, 3(1), 9].

The fragrant flowers of *N. arbor-tristis* are esteemed as votive offerings in temples and made into garlands. They contain an essential oil similar to that of jasmine. The oil obtained by the water-distillation method (yield, 0.0045%) had the following characteristics: sp. gr.^{33°}, 0.9044 ; n^{20} , 1.4825 ; [α]_D+2.4° ; acid val., 8.2 ; ester val., 61.3 : sol. in 1 vol. abs. alcohol with slight turbidity. The concrete, obtained by extraction with benzene in a yield of 0.058%, gives on steam-distillation 10.5% of otto. The concrete has the following characteristics: m.p., 33-34° ; congeal. p., 30-31° ; acid val., 23.5 ; and ester val., 38.19 (Gupta et al., Perfum. essent. Oil Rec., 1954, 45, 80).

The bright orange corolla tubes of the flowers contain a colouring matter, nyctanthin, which is identical with α -crocin (C₂₀H₂₄O₄) from saffron. Nyctanthin occurs in the material in a concentration of c. 0.1%, probably as a glucoside. The corolla tubes were formerly used for dyeing silk, sometimes in conjunction with safflower, turmeric, indigo or *kath*. For dyeing purposes, the fabric was steeped in a hot

NYCTANTHES

or cold water decoction of the material. It imparts a beautiful, but fleeting, orange or golden colour ; the addition of lime juice or alum to the dye bath is reported to render the colour more permanent. Besides the colouring matter, the flowers contain d-mannitol, tannin and glucose (Lal, *Proc. nat. Inst. Sci. India*, 1936, 2, 57 ; Mayer & Cook, 79 ; Burkill, *Agric. Ledger*, 1908, 7).

The seed kernels (56% of the seeds) yield 12–16% of a pale yellow-brown fixed oil with the following characteristics: d_{40}^{20} , 0.9157 ; n_{D}^{20} , 1.4675 ; sap. val., 185.5 ; iod. val. (Hanus), 82.2 ; acet. val., 19.28 ; acid val., 15.75 ; R.M. val., 0.1 ; and unsapon. matter, 2.4%. The oil consists of the glycerides of linoleic, oleic, lignoceric, stearic, palmitic and probably myristic acids. β -Sitosterol is the main component of the unsaponifiable matter. A tetracyclic triterpenoid acid, named nyctanthic acid (probably $C_{30}H_{48}O_2$, m.p. 222.5–23.5°), is deposited on keeping the oil for several weeks at 0° (*Chem. Abstr.*, 1939, 33, 4447 : Turnbull *et al.*, *J. chem. Soc.*, 1957, 569).

The leaves of the plant contain tannic acid, methyl salicylate, an amorphous glycoside (1%), mannitol (1.3%), an amorphous resin (1.2%) and a trace of volatile oil. They contain also ascorbic acid (30 mg./100 g.) and carotene ; the ascorbic acid content increases on frying the leaves in oil. The bark contains a glycoside (m.p. 86–88°) and two alkaloids, one soluble in water and the other soluble in chloroform. The glycoside increases the amplitude of the frog's heart in small doses, but in large doses diastolic period is decreased till the heart stops with auriculoventricular block ; it also depresses the central nervous system. The water soluble alkaloid stimulates the ciliary movements of oesophagus ; the chloroform soluble alkaloid has no such action. The alkaloids and the glycoside have little effect on blood pressure or respiration (Van Steenis-Kruseman, *Bull. Org. sci. Res. Indonesia*, No. 18, 1953, 38 ; Lal & Dutt, *Bull. Acad. Sci. Unit. Prov.*, 1933–34, 3, 83 ; Basu *et al.*, *J. Indian chem. Soc.*, 1947, 24, 358 ; Neogi & Ahuja, *J. sci. Res. Banaras Hindu Univ.*, 1960–61, 11, 196).

The wood (wt., 880 kg./cu. m.) is brown, close-grained and moderately hard. It forms a good batten base for tile or grass thatch roofs. Young branches are suitable for making baskets (Gamble, 469 ; Cowen, 122 ; Witt, 145).

The bark of the tree may be used as a tanning material and leaves are sometimes used for polishing wood and ivory. The leaves of the plant are anti-

bilious and expectorant and are useful in fevers and rheumatism. A decoction of leaves is given for sciatica. Extracted juice of leaves is acrid and bitter, and useful as cholagogue, laxative, diaphoretic and diuretic ; it is given to children for the expulsion of round and thread worms. The bark of the plant is expectorant. Powdered seeds are used as an application for scurfy affections of the scalp (Kanjilal, P. C., 227 ; Kanny Lall Dey, 207 ; Kirt. & Basu, II, 1527–28).

NYMPHAEA Linn. (*Nymphaeaceae*)

A genus of perennial rhizomatous aquatic herbs widely distributed in temperate and tropical regions. Five species occur in India ; a few species are grown in gardens for ornamental purposes.

Known as Water-Lilies, many species of *Nymphaea* bear showy flowers and are highly prized in aquatic horticulture. Numerous local varieties and cultivated hybrids are known. Some of them are day bloomers opening with the rising of the sun ; some bloom only in the night and open after sunset ; a few are fragrant. Natural hybridization occurs wherever two or more species are grown in the same pond, and the hybrids may be fertile or sterile. Important among the horticultural types grown in India are the Marliac and Laydekeri hybrids derived from *N. alba* Linn., *N. mexicana* Zucc., *N. odorata* Ait., *N. tetragona* Georgi and others. They are hardy and require 60–90 cm. of water for growth (Bailey, 1949, 382 : Bailey, 1947, II, 2306 ; Wood, *J. Arnold Arbor.*, 1959, 40, 97 ; Harler, 228 ; Gopalaswamiengar, 521 ; Percy-Lancaster, 429).

N. alba Linn. EUROPEAN WHITE WATER-LILY
D.E.P., V, 436 ; Fl. Br. Ind., I, 114 ; Coventry, Ser. I., Pl. 12.

KASHMIR—*Brimposh, nilofar, kamud.*

A perennial aquatic herb found in the lakes of Kashmir, at altitudes below 1,800 m. Leaves rounded, cordate, entire ; rhizome black ; flowers solitary, white, 10–13 cm. across, floating ; fruit a spongy berry ripening under water ; seeds minute, striate, punctate, buried in pulp.

The starchy rhizomes and seeds of the plant are eaten in times of scarcity ; rhizomes are boiled before they are consumed and seeds are parched. The rhizomes contain : starch, 46.0 ; crude fibre, 10.0 ; crude protein, 6.4 ; and ash, 10.8% ; an alkaloid nymphaecine ($C_{14}H_{22}O_2N$, m.p. 76–77°) with a pyrrole ring, a glucoside and tannins are present. Seeds contain c. 47% starch ; the fatty oil of the seeds



NYCTANTHES ARBOR-TRISTIS — IN FLOWER

contains di-, tri- and tetraenoic acids (Wehmer, I, 308; *Chem. Abstr.*, 1933, 27, 5782; 1949, 43, 137; 1945, 39, 5327; Henry, 758; Howes, 1953, 282).

The alkaloid nymphaeine is present in all parts of the plant, except the seeds. It is toxic to frogs and produces tetanus-like symptoms. Alcoholic extracts of the rhizome (containing the alkaloid) have a mild sedative and spasmolytic action; they do not significantly depress the heart; in large doses, they have a paralysing action on the medulla (Irvine & Trickett, *Kew Bull.*, 1953, 363; Henry, 758; *Chem. Abstr.*, 1945, 39, 5327).

The leaves of the plant contain a flavone glucoside, myricitrin. A glycoside nymphalin (m.p. 40°) with digitalis-like action has been identified in the flowers. Various parts of the plant contain ascorbic acid; the values recorded for the fruit nodules and foliage are 235 mg. and 170 mg./100 g. respectively (Hoppe, 606; *Chem. Abstr.*, 1943, 37, 5758; 1935, 29, 3735; 1937, 31, 3571, 3572).

The rhizomes of the plant are reported to have been used for tanning purposes. They are astringent; a decoction of the fresh rhizome is given in diarrhoea. An infusion of flowers and fruits is diaphoretic and used for diarrhoea (Howes, 1953, 282; Steinmetz, II, 318; Kirt. & Basu, I, 111).

N. nouchali Burm. f. syn. *N. pubescens* Willd.; *N. lotus* Hook. f. & Thoms. non Linn.; *N. rubra* Roxb. ex Salish. INDIAN RED WATER-LILY

D.E.P., V, 436; III, 318; Fl. Br. Ind., I, 114.

HINDI—*Kanval*, *koka*, *koi*, *bhenght*; BENG.—*Shaluk*, *rakto-kambal*, *nal*; MAR.—*Lalakamal*, *raktakamal*; GUJ.—*Kanval*, *nilophal*; TEL.—*Allitamara*, *tella-kalava*; TAM.—*Alli-tamarai*, *vellambal*; KAN.—*Nyadale huwu*; MAL.—*Periambal*, *neerambal*; ORIYA—*Dhabalakain*, *rangkain*.

PUNJAB—*Chota kanwal*; MUNDARI—*Pundi salukid*; ASSAM—*Mokuva*, *nal*.

A large aquatic herb with short, erect, roundish, tuberous rhizome found in *jheels*, tanks, ponds and ditches throughout the warmer parts of India. Leaves peltate, 15–25 cm. diam., orbicular or reniform, sagittate when young, sharply sinuate-toothed, pubescent below; flowers solitary, variable in colour from deep red to pure white; fruit a spongy berry, 3 cm. diam., ripening under water; seeds minute, broadly ellipsoid, rough, buried in pulp.

This species is distinct from *N. lotus* Linn. (White Egyptian Water-Lily) which does not occur in India.



FIG. 25—NYMPHAEA NOUCHALI

Also *N. pubescens* and *N. rubra*, which were formerly considered to be distinct from this species on the basis of the colour of flowers and pubescence of leaves, are thus regarded as synonyms. It has been shown that wide variation in colour is found even in one and the same flower [Kirt. & Basu, I, 112; Santa-pau, *Rec. bot. Surv. India*, 1953, 16(1), 7].

All parts of the plant are eaten in times of scarcity. The starchy rhizomes are eaten raw or boiled; they are sometimes baked. Analysis of rhizomes (from Philippines) gave the following values: moisture, 53.95; crude protein, 5.87; fat, 1.06; starch, 27.37; crude fibre, 1.55; other carbohydrates, 9.07; and ash, 1.13%. Flowering stalks and unripe fruits are used as vegetable; the former are used also as salad and ingredient of stews (Paton & Dunlop, *Agric. Ledger*, 1904, 37; Valenzuela & Wester, *Philipp. J. Sci.*, 1930, 41, 85; Brown, 1941, I, 529).

The seeds are edible and can be eaten raw or after parching; they may also be ground into flour and made into a kind of bread or cooked into *kanji* with water. They produce toxic effects when consumed in

NYMPHAEA

excessive quantities. Analysis of seeds gave the following values: moisture, 12.05 ; crude protein, 7.95 ; fat, 0.94 ; carbohydrates, 77.86 ; fibre, 0.68 ; and ash, 0.52% (Paton & Dunlop, loc. cit. ; Koch, *Trop. Agriculturist*, 1936, **87**, 297).

The rhizome is considered demulcent and used for dysentery and dyspepsia. Flowers are astringent and cardiotonic. Some preparations, known as *Ghillad*, *Gulkand*, etc. are reported to be prepared from the flowers. Seeds are used as a cooling medicine in cutaneous diseases (Kirt. & Basu, I, 112 ; Fl. Delhi, 54).

N. stellata Willd. INDIAN BLUE WATER-LILY

D.E.P., V, 438 ; III, 318 ; Fl. Br. Ind., I, 114.

HINDI—*Nilpadma*, *nilkamal* ; BENG.—*Nilshapla*, *nilpadma* ; MAR.—*Krishnakamal*, *poyani* ; GUJ.—*Nilkamal* ; TEL.—*Nallakalava*, *nitikulava* ; TAM.—*Karu neythal*, *nilotpalam* ; MAL.—*Sitambel* ; ORIYA—*Subdikain*.

PUNJAB—*Bambher*, *nilpadma* ; DELHI—*Chotakamal*.

A large, perennial, aquatic herb with a short,



FIG. 26—NYMPHAEA STELLATA—IN FLOWER

ovoid, acute rootstock, found in ponds and ditches throughout the warmer parts of India. Leaves peltate, 12–20 cm. in diam., orbicular or elliptic, entire, or obtusely sinuate-dentate, glabrous on both surfaces, often blotched with purple beneath ; flowers solitary, blue, white, purple or pink ; fruit a spongy berry ; seeds minute, longitudinally striate.

This species includes several varieties differing in colour and size of flowers. It is often confused with *N. caerulea* Sav. (Egyptian Blue Lotus) and *N. capensis* Thunb. (Cape Blue Water-Lily), but can be distinguished from them by the dentate nature of leaves, smaller flowers and absence of fragrance (Berkill, II, 1566 ; Firminger, 626 ; Gopalaswamiengar, 521).

Various parts of the plant are edible. The pyriform, egg-sized rhizomes, tender leaves and flower peduncles are used as vegetable. In Ceylon, efforts have been made to cultivate this species as an economic crop in paddy fields, which are usually left uncultivated during the monsoon period. By planting the rhizomes with suitable spacing and proper manuring, a harvest of c. 2,500 kg. of rhizomes per hectare can be obtained. The crop is susceptible to damage by a caterpillar, *Nymphula* spp., which feeds on leaves and flowers (Irvine & Trickett, *Kew Bull.*, 1953, 363 ; de Soyza, *Trop. Agriculturist*, 1936, **87**, 371).

The rhizome is consumed boiled or after roasting. Analysis of the dried tubers (from Ahmadabad) gave the following values: moisture, 4.20 ; fat, 0.45 ; proteins, 14.56 ; carbohydrates, 67.49 ; fibre, 5.45 ; and ash, 7.85% (Irvine & Trickett, loc. cit. ; Pathak, *Agric. J. India*, 1920, **15**, 40).

The seeds are eaten in times of scarcity. They are made into flour and made into bread along with wheat or barley flour : it, however, imparts an objectionable odour to the bread. The seeds contain: moisture, 5.40 ; fat, 1.30 ; protein, 11.31 ; carbohydrates, 70.59 ; fibre, 7.45 ; and ash, 3.95% (Irvine & Trickett, loc. cit. ; Pathak, loc. cit.).

The powdered rhizome is given in dyspepsia, diarrhoea and piles. An infusion of rhizomes and stems is considered emollient and diuretic ; it is used for blennorrhagia and diseases of the urinary tract. In Malagasy (Madagascar), leaves are applied topically in erysipelas. Macerated leaves are used as a lotion in eruptive fevers. A decoction of flowers is considered narcotic. Seeds are stomachic and restorative (Kirt. & Basu, I, 114).

N. tetragona Georgi syn. *N. pygmaea* Ait. PYGMY
WATER-LILY

Fl. Br. Ind., I, 115; Fl. Assam, I, 64.

A dwarf aquatic herb found in the Himalayas and also in swamps on Khasi hills, at an altitude of 1,200–1,800 m. Rootstock unbranched, short; leaves ovate, entire, green above, blotched with red-brown when young, dull red beneath. flowers white, 3–7 cm. across.

This dwarf lily is a free bloomer and can be grown readily from seeds; it is suitable for aquaria. It has been much used in hybridization with other species, contributing to some of the Marliac and Laydekeri hybrids (Bailey, 1947, II, 2313; Chittenden, III, 1389).

The leaf buds and seeds of this plant are eaten. Analysis of seed kernels gave the following values: water, 12.5; starch, 47.0; protein, 21.3; fat, 2.6; pentosans, 3.6; fibre, 2.8; and ash, 4.5%; seeds are rich in phosphorus. Leaves and roots are reported to contain an alkaloid [Irvine & Trickett, *Kew Bull.*, 1953, 363; Wchmer, I, 308; Krishna & Badhwar, *J. sci. industr. Res.*, 1947, 6(2), suppl., 24; *Chem. Abstr.*, 1956, 50, 11441].

Nymphoides — see *Limnanthemum*

NYPA Wurmb. (*Palmae*)

A monotypic genus of palms distributed in the Indo-Malaysian region and Australia; it has been introduced into some tropical and sub-tropical countries.

N. fruticans Wurmb. NYPA PALM

D.E.P., V, 430; C.P., 776; Fl. Br. Ind., VI, 424; Blatter, 553, Pl. 106.

BENG.—*Gulga, gabna, golphal* (fruits). *golpatta* (leaves); GUJ.—*Pardeshi-tadio*.

ANDAMANS—*Poothada*.

A prostrate palm with a stout, branched, creeping rhizome found in the tidal swamps of Sundarbans in Bengal and in Andaman Islands; it has also been recorded from Saurashtra. Leaves erect, up to 9 m. in length, pinnatisect: petiole stout: leaflets linear-lanceolate, 1.2–1.5 m. long; spadix terminal, 1.2–2.1 m. long, drooping when in fruit, flowers monoecious; fruit globose, c. 30 cm. in diam., syncarp of many obovoid, 1-celled, 1-seeded carpels, each 10–15 cm. long, with fleshy and fibrous pericarp and spongy endocarp; seed as large as a hen's egg, grooved on one side, hard when mature; endosperm horny, hollow.

Nipa palm often forms gregarious growth in

mangrove swamps and tidal forests. It grows best in alluvial deposits of clayey loam with sufficient salt and is useful for stabilizing soil. It is a light demander. It reproduces naturally by seeds and detached branches of rhizome and attains a height of 1.5–2 m. during the first year. Nipa makes an attractive plant in water gardens and may be grown in pots kept in water with a small amount of salt dissolved in it (Troup, III, 973; Bhattacharji, *Indian For.*, 1916, 42, 509; Bor, 350; Gopalaswamiengar, 375).

The palm is much valued, particularly in the Philippines, for the sweet sap tapped from the stalk of the spadix. The sap may be used for making jaggery, sugar, alcohol and vinegar. The inflorescence is conveniently situated near the ground for the collection of sap. The palm is ready for tapping, after the second flowering, when about 5 years old, and tapping may be continued for 50 years or more. If the plant bears more than one spadix, only one of them is tapped and the other removed. Tapping starts some time after or just before fruit formation and sap collection is continued for about three months. The average yield of sap per plant during the season is reported to be 43 litres (Burkill, II, 1558; Brown, 1941, I, 321; Browne, 285).

Fresh nipa sap contains c. 17% sucrose and only traces of reducing sugars; it was formerly regarded as a promising source of commercial sugar. Fermentation of sap, however, sets in readily, and transport of sap in fresh condition to manufacturing centres presents practical difficulties. Vinegar containing 2–3% acetic acid may be obtained by allowing the fermented sap to stand for about 2 weeks. Considerable quantities of alcohol were being produced in the Philippines by the distillation of the fermented nipa sap. With the expansion of sugarcane cultivation and the availability of cheap molasses, the importance of nipa, as a source of alcohol, has dwindled (Brown, 1941, I, 321, 323, 326–27; Browne, 286).

The leaves of nipa are much valued as thatching material and large quantities of leaves are sold in Sundarbans for use as thatch. Only mature leaves are harvested for this purpose. Leaves are also used for making shingles and coarse mats, baskets and bags; young unexpanded leaflets are used for wrapping cigarettes. Midribs are used for making coarse brooms and as fuel (Burkill, II, 1557–58; Blatter, 556; Brown, 1941, I, 316; Trotter, 1940, 305; *For. Abstr.*, 1958, 19, 372).

Tender stem buds are eaten as vegetable; young peduncles and immature seeds (starch content,

c. 70%) are eaten raw or cooked ; prolonged boiling, however, makes the seeds tough. Mature seeds are hard ; attempts to produce buttons from these proved unsuccessful as they are readily attacked by fungi (Burkill, II, 1560 ; Bhattacharji, loc. cit. ; Datta, *Indian For.*, 1928, 54, 302 ; *Bull. imp. Inst., Lond.*, 1933, 31, 5).

The leaflets contain c. 10.2% tannin and 15.2% hard-tans ; they may be used for direct tanning of light leather. Leaves and mesocarp of fruit yield a fibre. Pounded leaves are used in the form of cataplasin or lotion for ulcers. The juice of young shoots is taken internally and the pulp left behind applied externally in herpes. The ash obtained by burning roots and leaves is considered useful for relieving toothache [Das, *Tanner*, 1949-50, 4(9), 12 ; Bhattacharji, loc. cit. ; Kirt. & Basu, IV, 2590 ; Burkill, II, 1561].

NYSSA Linn. (*Nyssaceae*)

A small genus of trees or shrubs distributed in North America and Indo-Malaysian region. Two species are found in India.

N. javanica Wang. syn. *N. sessiliflora* Hook. f. & Thoms.

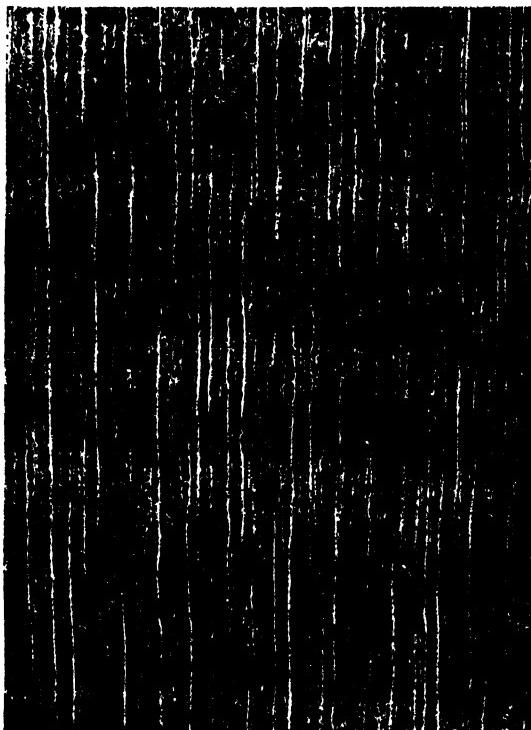
D.E.P., V, 438 ; Fl. Br. Ind., II, 747.

BENG.—*Kalay, chilauni*.

NEPAL.—*Lekh chilaune* ; LEPCHA—*Hlo-sumbrung* ; ASSAM—*Gaharichopra*.

A large tree, up to 24 m. in height, with a straight, fairly cylindrical bole often up to 9 m. in length and 2.4 m. in girth, found in the eastern Himalayas at altitudes of 1,500-2,400 m. and in Assam up to 1,500 m. Bark grey or brown, rough ; leaves elliptic-lanceolate, ovate or obovate, punctate ; flowers in heads, unisexual, green ; berry ovoid, 1.25 cm. x 0.8 cm. ; seeds albuminous.

The tree yields fairly good, non-ornamental timber and has been recommended for cultivation in tea estates. The wood is yellowish white when first exposed, becoming brownish with age, somewhat lustrous, straight-grained, even- and medium-fine-textured, smooth, moderately hard, strong and light (sp. gr., c. 0.61 ; wt., 625 kg./cu. m.). It is easy to season, but somewhat liable to stain ; open stacking of the sawn material in a well ventilated situation has been recommended. The timber is considered durable



F.R.I., Dehra Dun. Photo : S. S. Joshi

FIG. 27—NYSSA JAVANICA—TRANSVERSE SECTION OF WOOD (x10)

under cover, but is susceptible to insect attack. It is easy to saw and works to a bright, smooth surface, taking a good polish. It turns well on the lathe and requires little finishing by hand (Pearson & Brown, II, 612-14 ; Macalpine, *Tocklai exp. Sta. Memor.*, No. 24, 1952, 163).

The wood is used for house construction and for making tea chests. It is suitable for furniture, especially backing boards, bottoms and sides of cupboards and drawers. The fruit is reported to be eaten ; it has a sweet odour, but a bitter acid taste [Pearson & Brown, II, 614 ; Fl. Malesiana, Ser. I, 4(1), 31].

N. sylvatica Marsh. syn. *N. multiflora* Wang. (BLACK TUPELO), a tall tree native of N. America, has been introduced in the Lloyd Botanic Garden, Darjeeling. It yields a useful timber employed principally for making crates, boxes, rollers and paper pulp [Biswas, *Rec. bot. Surv. India*, 1940, 5(5), 439 ; Record & Hess, 412].

O

Oak — see **Quercus**

Oak, Ceylon — see **Schleichera**

Oak moss — see **Lichens**

Oak, Silky or Silver — see **Grevillea**

Oats — see **Avena**

OCHLANDRA Thw. (*Gramineae*)

A small genus of bamboos distributed in the Indo-Malayan region and Malagasy (Madagascar). About 6 species are found in India.

O. travancorica Benth. ex Gamble

C.P., 103; Fl. Br. Ind., VII, 419.

TAM.—*Irul, eera-katti, odai, nanal*; KAN.—*Carte*;
MAL.—*Eetta, vei*.

A shrubby bamboo found in Mysore, Travancore and Anamalai and Tirunelveli hills up to an altitude of 1,500 m. Culms up to 6 m. in length and 5 cm. in diam., with rough, thin-walled, solid internodes up to 1.5 m. in length; leaves broadly oblong-lanceolate; flowers large; fruit ovoid, with fleshy pericarp.

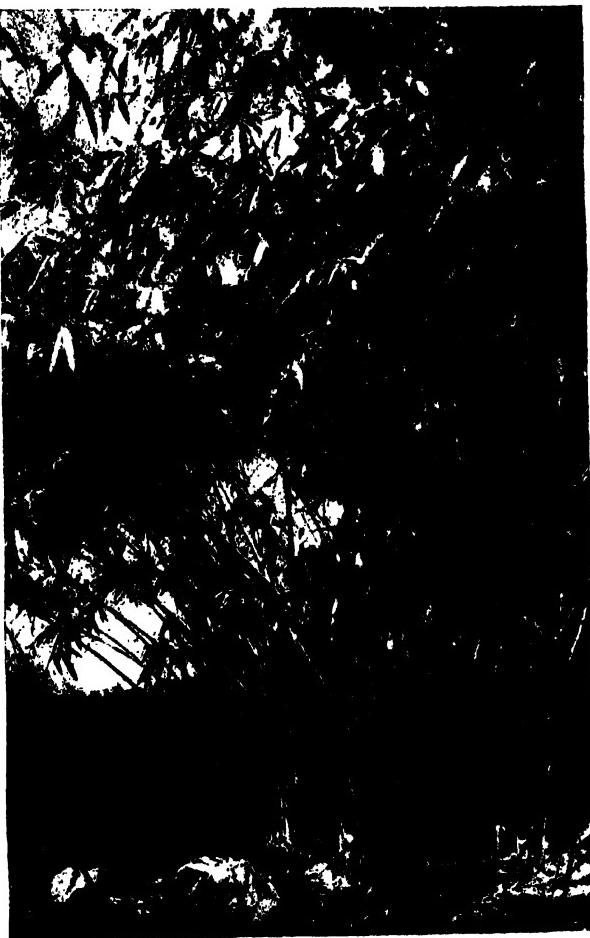
This bamboo grows gregariously in evergreen forests covering extensive areas as dense undergrowth. It is grown along paddy fields as a soil binder. In Kerala forests, it is worked on a four year felling cycle (Rama Rao, 448; Mathauda, *Symp. Timb. & Allied Prod.*, National Buildings Organisation, New Delhi, 1959, 13).

The mature culms of *eetta* are used in the manufacture of paper pulp. The average composition of culms is as follows (oven-dry material): cellulose, 61.8; lignin, 26.9; pentosans, 17.8; hot water solubles, 5.1; ash, 2.6; and silica, 2.1%. Pulping tests have shown that among the Indian bamboos, *eetta* gives the maximum yield of pulp (unbleached, 48.3%, bleached, 45.8%) and has the longest fibre (length, up to 9 mm.; av. 4 mm.). About 25,400 tonnes of the bamboo are annually available for paper manufacture in Kerala; an equal quantity can be obtained from Tirunelveli dist. (Madras) (Wlth India—Raw Materials, I, 145-53; *Indian For.*, 1952, 78, 348).

The possibility of using *eetta* reeds for the production of viscose rayon pulp has been investigated. Analysis of bleached pulp (yield, 32%) prepared by the water prehydrolysis sulphate process, followed by

multi-stage bleaching and refining, gave the following values: α-cellulose, 96.9; pentosans, 4.1; and ash, 0.11%; iron, 33 p.p.m.; copper number, 0.7%; cuprammonium viscosity, 13.9 cp.; bleaching degree, 85.2% GE (General Electric Brightness Tester); and filtration factor of viscose prepared from pulp, 330. The pulp freed from iron is suitable for rayon manufacture (Bhat & Virmani, *Indian Pulp Pap.*, 1961, 62, 16, 317).

Eetta bamboo is used for temporary huts and thatching. Its durability can be considerably enhanced by pre-treatment with preservative and fire proofing agents. Impregnation of dried material with



F.R.I., Dehra Dun

FIG. 28—OCHLANDRA TRAVANCORICA

OCHLANDRA

a solution containing: boric acid, 3 ; copper sulphate, 1 ; zinc chloride, 5 ; and sodium dichromate, 6 parts/100 parts of water, enhances the average life of treated material to c. 18 years as against 6 months for the untreated material. The culms are used for making mats, baskets, umbrella handles and walking sticks ; they are suitable for match boxes and splints. The leaves are eaten by elephants ; they may be used as fodder for horses during scarcity (Rama Rao, 448 ; Purushotham & Rana, *Indian For.*, 1953, **79**, 243 ; Trotter, 1940, 240-41 ; Krishnamurti Naidu, 154 ; Bourdillon, 355).

O. scriptoria (Dennst.) Fischer syn. *O. rheedii* Benth. ex Gamble (MAL.—*Ottal, kolanji, ammet*) is a shrubby, gregarious bamboo with culms, up to 5 m. in length and 2.5 cm. in diam., found at low elevations in Kerala. It is suitable for planting along margins of ponds and paddy fields as soil binder. It is used in the same way as *O. travancorica* for paper pulp and for making mats and baskets (Firminger, 287 ; Bhat, *Indian Pulp Pap.*, 1951-52, **6**, 30 ; Rama Rao, 448).

O. wightii Fischer syn. *O. brandisii* Gamble is found in Kerala and Tirunelveli hills. It is suitable for paper pulp (Trotter, 1940, 345).

OCHNA Linn. (*Ochnaceae*)

A genus of trees or shrubs distributed in tropical and sub-tropical Asia, Africa and America. About 7 species are found in India.

O. jabotapita Linn. syn. *O. squarrosa* Linn.

D.E.P., V, 439 ; Fl. Br. Ind., I, 523 in part ; *Taxon*, 1962, **11**, 51.

TEL.—*Sunari, yerrajuvi* ; TAM.—*Chilanti, she-rundi* ; KAN.—*Narole, mudah* ; ORIYA—*Koniari, nobunisero*.

BHAR.—*Champa baha* ; BOMBAY—*Kanak champa*.

A small handsome tree or a shrub found in Assam, Bihar, Orissa and the Deccan Peninsula. Bark brown or grey, thin, smooth ; leaves oblong-lanceolate, elliptic or obovate ; flowers in umbellate panicles, large, yellow, fragrant ; fruit compound, consisting of 3-6 drupes, surrounded by the persistent calyx.

The plant is frequently cultivated in parks and gardens and may be propagated by seeds or cuttings (Benthall, 97 ; Gopalaswamiengar, 282).

The wood (wt., c. 801 kg./cu. m.) is reddish brown, handsome, close-grained, elastic and hard. It warps badly and requires careful seasoning. It is used for



FIG. 29—OCHNA JABOTAPITA—FLOWERING BRANCH

walking sticks and is suitable for inlaying and carving (Gamble, 136).

The bark is a digestive tonic. Boiled leaves are used as an emollient cataplasm. A decoction of the root is reported to be used in menstrual complaints and for consumption and asthma. The plant is lopped for fodder in Bombay and Orissa (Kirt. & Basu, I, 518 ; Laurie, *Indian For. Leaf.*, No. 82, 1945, 15).

O. pumila Buch.-Ham. ex D. Don (BHAR & ORISSA—*Champa baha, bhuin champa, tindu ret*) is a handsome undershrub with a woody rootstock, oblanceolate or obovate leaves and large yellow flowers found in the outer Himalayas and the sub-Himalayan tract from Kumaun to Assam, extending southwards to Madras State ; it is also cultivated in gardens. The root finds uses similar to those of *O. jabotapita* ; it is also reported to be used by the Mundas for epilepsy. The leaves are said to be used as poultice in lumbago and ulcers (Kirt. & Basu, I, 518 ; Chopra, 1958, 601 ; Bressers, 25 ; Mooney, 40).

O. wallichii Planch. (GARO—*Khimdabeng*) is a small tree found in Assam and the Andaman and Nicobar Islands ; it has also been recorded from Salem in Madras State. The wood (wt., 865 kg./cu. m.)

is reddish brown, moderately hard and close-grained. It is used in hut construction and for rice pounders (Fl. Madras, 1872; Gamble, 136; Parkinson, 114 Fl. Assam, I, 220).

O. wightiana Wall. ex Wight & Arn. (Fl. Br. Ind.) in part (TAM.—*Kat-kari*) is a small tree or a shrub found in Travancore. The wood is pale yellow, elastic and light and is used for walking sticks (Bourdillon, 67).

Ochrocarpus — see **Mammea**

*OCHROMA Sw. (*Bombacaceae*)

A small genus of trees native of tropical America. *O. pyramidale*, the source of the well known Balsa wood of commerce, has been introduced and cultivated in India.

O. pyramidale Urban syn. *O. lagopus* Sw. BALSAL

Raizada, Indian For., 1947, 73, 155.

TRADE—*Balsa*.

A tree, 18 m. or more in height with a clean bole c. 9 m. in length and 1.5 m. in girth, cultivated in some parts of S. India. Leaves large, cordate, usually shallowly lobed; flowers at ends of branches, yellowish or reddish; capsules elongate, 5-valved; seeds many, enveloped in silky floss of pale reddish colour.

Balsa has been grown in plantations at Kannoth in Wynnaad forest division of Kerala and Top-slip in South Coimbatore forest division of Madras. It is cultivated on a small scale in a few other places, e.g. Bangalore and Vishakhapatnam, and is expected to do well in Coorg, Assam, Bengal and Andaman Islands (Chowdhury *et al.*, I, 190; Chelvarajan, Comp. Wood, 1953-54, 1, 125; Rao, Curr. Sci., 1953, 22, 18; Nair, Indian For., 1953, 79, 163).

The tree flourishes in low lands and foothills up to c. 600 m., in a damp climate with temperatures varying between 20° and 35° and a minimum rainfall of 125 cm. distributed over the greater part of the year. It is known to grow in a wide variety of soils, but thrives best in rich alluvial loams along banks of perennial streams and rivers; good drainage is essential. Balsa is a strong light demander and requires overhead light from the very beginning (Nair, loc. cit.).

The tree flowers and bears fruits when 3-4 years



FIG. 30—OCHROMA PYRAMIDALE—CAPSULES

old. The seeds are light and readily dispersed by wind, providing abundant natural regeneration under favourable conditions. For artificial reproduction, seeds are obtained from capsules gathered from trees in March-April, just when they begin to open; seeds retain their viability for 16-18 months. They may be sown directly in the field or seedlings may be raised in baskets or bamboo tubes and planted out when 15-20 cm. high. In either case, the land should be prepared by thorough clearing and burning. The best time for sowing seeds is middle of February; transplanting is done in May-June. Seedlings are liable to damping off disease and attack by cut-worms; pre-treatment of seeds with cold water for 12 hours and dusting of seed beds with gammexane or hexadol (10%) reduces the mortality of seedlings. In large scale cultivation, a spacing of 5 m. × 5 m. is adopted; in poor soils and dry localities, closer espacement, 3.5-4.5 m. × 3.5-4.5 m., is recommended. Soil working, mulching and cultivation of nurse crops, such as *Cajanus cajan* and *Tephrosia candida* DC., are beneficial. Growing of *taungya* crops, like *Setaria italica* Beauv. and *Pennisetum typhoides* Stapf & Hubbard, is effective in suppressing weed growth (Nair, loc. cit.; Indian For., 1952, 78, 359).

Balsa is a fast growing tree. Available growth data are scanty and sometimes conflicting; generally, under favourable conditions an average height of 2.4 m. is reached at the end of the first year and the exploitable height of 15-18 m. and a diameter of c. 30 cm. is reached in 4-6 years. As the tree ages the wood tends to lose its porous property. The growth

* Many authors regard this genus as monotypic; the species described as distinct by some authors are regarded for all practical purposes to be synonyms of *O. pyramidale*.

OCHROMA

in height is usually better in sandy and alluvial loams and increment in girth is significantly more in dark clayey loams. Balsa of commerce is obtained, for the most part, from trees 6–9 years old (Nair, loc. cit.; *Indian For.*, 1952, **78**, 359).

Balsa wood is whitish in colour with a tinge of pink or grey; heartwood, when present, is pale brown or reddish. The wood has a smooth velvety feel, is somewhat lustrous, straight-grained, medium to coarse-textured and elastic. The weight varies from 80 to 336 kg./cu.m., but the requirement for commercial samples is exacting and only the best knot-free lengths weighing 128–224 kg./cu.m. are accepted. Balsa wood is strong for its weight and is characterized by its buoyancy.

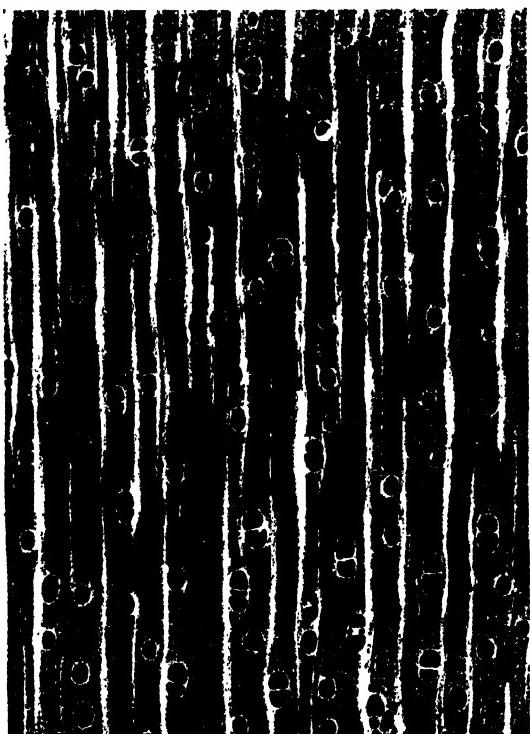
Balsa can be air-seasoned with little degrade; quick conversion and end-stacking of boards against horizontal support or stacking in alternate parallel layers is recommended. Kiln-seasoning gives better results. The wood is not durable and decays quickly in a humid atmosphere; impregnation with hot melted paraffin or a water repellent preservative

provides adequate protection; application of paints with a bitumen base or varnishes with a bakelite base generally reduces water absorption. It is also susceptible to sap stain and borer attack. Balsa wood works easily with sharp edged tools. It is easy to screw and nail without any splitting, but does not hold them well under strain. It glues well and is best joined this way. It also stains and polishes well (Chowdhury et al., I, 191; Nair, loc. cit.; Fletcher, *Econ. Bot.*, 1951, **5**, 107; *For. Abstr.*, 1950–51, **12**, 213; Titmuss, 25–26).

Two defects encountered in balsa wood are 'water-heart' and 'crocho'. The former shows up as a wet zone in the lower 1.5–2.5 m. of butt logs; there is an abrupt line of demarcation between water-heart and normal wood. Such a defective wood does not float; it cannot be seasoned properly and is not acceptable according to specifications. Some boards of balsa also show pockets or ribbons of unusually light wood (wt., <80 kg./cu.m.) of crocho (cork) which break like decayed timber (Chelvarajan, loc. cit.).

Balsa is the lightest of commercial timbers and is valued for a variety of special uses. Balsa wood is used as a sandwich material in certain parts of aircraft and also in gliders and seaplanes. It is used also for rafts, floats, lifebuoys and other life-saving equipment. Balsa possesses good heat insulating properties and is used for lining refrigerators, auto-truck bodies and holds of ships. It is also a sound deadener and useful for ceilings and partitions. Its resiliency combined with strength and a smooth soft surface makes it an excellent shock absorbing material. It is employed as a substitute for cork and may be used for cigarette tips. Because of its remarkable properties and specialized uses, balsa wood has gained commercial prominence, particularly since the last World War. At present, Ecuador furnishes the bulk of the world supply. It is not produced in sizeable quantities in India at present and current demands are met by imports. Preliminary tests on balsa grown in Bangalore and Wynad (Kerala State) have shown that under suitable conditions the wood may satisfy the strength and density requirements for use in aircraft industry (Chowdhury et al., I, 192–93; Nair, loc. cit.; Hill, 108; Narayananamurti & Jain, *Indian For.*, 1954, **80**, 338; ibid., 1952, **78**, 358; ibid., 1918, **44**, 138; Chelvarajan, loc. cit.).

Balsa wood has been tested as a raw material for paper pulp. Analysis of wood gave the following values (oven-dry basis): cellulose (Cross & Bevan),



F.R.I., Dehra Dun. Photo : S. S. Ghosh

FIG. 31—OCHROMA PYRAMIDALE—TRANSVERSE SECTION OF WOOD ($\times 10$)

75.80 ; lignin, 19.70 ; pentosans, 15.40 ; and ash, 0.64%. Digestion by the sulphate process gave a pulp (fibre length, 0.56–2.14 mm. ; diam., 0.014–0.112 mm. ; av. length/av. diam., 19) suitable for writing and printing papers ; pulp yields under optimum conditions (total chemicals, 21% ; digestion temp., 153° ; and digestion period, 6 hr.) were : unbleached, 56.4 and bleached, 51.2%. Standard pulp sheets showed the following properties : breaking length (Schopper), 9,680 m. ; stretch, 3.8% ; tear factor (Marx-Elmendorf), 70.9 ; burst factor, 80.3 ; and brightness ($MgO = 100$), 68 (Guha *et al.*, *Res. & Ind.*, 1960, 5, 392).

The floss covering the seeds resembles Silk Cotton [from *Salmalia malabarica* (DC.) Schott & Endl.]. The ultimate fibres have a length of 5.0–15.0 mm. and a diameter of 6–7 μ in the middle ; the fibres are somewhat lignified and the walls are specially thick at the base and apex and show the presence of granular matter. The typical fibre is yellow to nearly colourless under the microscope, flattened, often much folded, with indistinct outline and finely striated surface. It retains its resiliency for a long time and is chiefly used for stuffing cushions and mattresses, often in mixture with silk cotton (Matthews, 448–49).

The bark of balsa is reported to yield a strong fibre, sometimes used for cordage. Stem bark is reported to possess slow emetic properties ; root bark is aperient and diuretic (Skutch, *Nature Mag.*, 1947, 40, 377 ; Hocking, 152).

OCHROSIA Juss. (*Apocynaceae*)

A small genus of trees distributed in Mascarene Islands, tropical Asia, Australia and the Pacific Islands. One species occurs in India ; another has been introduced.

O. oppositifolia K. Schum. syn. *O. borbonica* Hook. f. (Fl. Br. Ind.), non J.F. Gmel.

D.E.P., V, 440 ; Fl. Br. Ind., III, 638.

A medium-sized ornamental tree with a straight bole found in the tidal forests of Andaman Islands. Bark yellowish grey ; leaves elliptic-obovate ; flowers in clusters, small, white ; fruit consisting of oblong twinned drupes, bright yellow or red when ripe.

The tree yields a sticky latex which is used for temporary caulking of boats. The wood is moderately hard and even-grained ; it may be used for light packing cases. The fruit is reported to be poisonous,

but the seed is edible. The leaves contain alkaloids, one of which is identical with methoxy-ellipticine isolated from *O. elliptica* (q.v.) (Burkill, II, 1570 ; Macmillan, 371 ; Lewis, 278–79 ; Buzas *et al.*, *C.R. Acad. Sci., Paris*, 1958, 247, 1390).

O. elliptica Labill., a small ornamental tree native of Australia and the Pacific Islands, has been introduced in Dehra Dun. The bark is reported to be used in malaria ; it contains alkaloids (total alkaloids c. 1%) but tests with bark extracts on experimental animals have given no indication of quinine-like action. Four crystalline alkaloids, elliptine ($C_{22}H_{28}O_5N_2$, m.p. 210–11.5°), ellipticine ($C_{17}H_{14}N_2$, m.p. 311–15° decomp.), methoxy-ellipticine ($C_{18}H_{16}ON_2$, m.p. 280–85° decomp.) and elliptinine ($C_{20}H_{24}O_2N_2$, m.p. 231–33°) have been identified in the leaves ; elliptine is identical with isoreserpiline. The fruit is poisonous but contains no alkaloids (Raizada & Hingorani, 31 ; Wehner, II, 989 ; *Chem. Abstr.*, 1940, 34, 4802 ; Webb, *Bull. Coun. sci. industr. Res. Aust.*, No. 232, 1948, 19 ; Goodwin *et al.*, *J. Amer. chem. Soc.*, 1959, 81, 1903).

OCIMUM Linn. (*Labiatae*)

A genus of aromatic herbs, undershrubs or shrubs distributed in the tropical and warm temperate regions of the world. Nine species are found in India of which three are exotic. Several *Ocimum* species yield essential oils which are valued in medicine and perfumery : a few are rich sources of camphor.

The nomenclature of *Ocimum* spp. and varieties is complicated and confused and it is difficult to classify the oils reported in literature according to the botanical nomenclature of plants from which they are derived. In several instances, oils derived from morphologically identical plants show different physico-chemical properties ; such plants may be typical cases of physiological forms. There are also cases of hybrids which yield oils similar to those of the parent plants. It has been suggested that *Ocimum* oils should be classified on the basis of their chemical composition rather than by their botanical origin (Guenther, III, 415 ; Menon, 24).

O. americanum Linn. syn. *O. canum* Sims HOARY BASIL.

D.E.P., V, 442 ; Fl. Br. Ind., IV, 607 ; Mukerjee, *Rec. bot. Surv. India*, 1940, 14(1), 17.

SANS. -Ajaka, gambhira, kuthera ; HINDI—Kala

OCIMUM

tulsi, mamri; TEL.—*Kukka tulasi*; TAM. & KAN.—*Nayi tulasi*; MAL.—*Kattu tulasi*.

LVSHAI—*Runhmui*.

An erect, sweet scented, pubescent herb, 30–60 cm. high, found growing in abundance near cultivated fields and on waste lands nearly throughout India. Leaves elliptic-lanceolate, entire or faintly toothed, almost glabrous, gland-dotted: flowers small, white, pink or purplish, in more or less closely set whorls in spiciform racemes: nutlets narrowly ellipsoid, punctulate, black. The plant is occasionally cultivated in gardens; it can be easily raised from seeds.

O. americanum yields a volatile oil useful as a perfume for soaps and cosmetics. The composition and properties of oils from different geographical regions vary: three types of oil may be distinguished, one containing methyl cinnamate as the principal constituent, the second containing *d*-camphor and the



FIG. 32—*OCIMUM AMERICANUM*—FLOWERING BRANCH

third, citral. It is uncertain whether the differences are attributable to soil and climatic conditions or to varietal or racial differences of the plant. The camphor yielding type has been grown on an experimental scale in Comoro Islands (Indian Ocean), Kenya, U.S.S.R., U.S.A. and North Germany, and yields of camphor ranging from 20 to 100 kg./ha. have been recorded. The Indian oil is of the citral type and may be used as a commercial source of citral or as a perfume for soaps and cosmetics. There is little demand for the oil in India [Guenther, III, 415–16, 419–22; Dhingra *et al.*, *Indian Soap J.*, 1951–52, 17, 85; *Perfum. essent. Oil Rec.*, 1950, 41, 405; Handa *et al.*, *J. sci. industr. Res.*, 1957, 16A(5), suppl., 19; Menon, 25].

Steam-distillation of the whole plant (from N. India) gave a pale yellow oil, in 0.7% yield, with an intense and characteristic odour of lemon and an appreciable note of lavender; another specimen of oil (from S. India) had a mild camphoraceous odour. The characteristics of oil obtained from different localities in India are given in Table 1. The oils contain citral (up to 60%) along with linalool, geraniol and citronellol and their esters, citronellal, methyl heptenone and methyl cinnamate; small amounts of eugenol, acetic acid and citronellic acid are present (Tayal & Dutt, *Proc. nat. Acad. Sci. India*, 1938, 8, 406; Sanjiva Rao *et al.*, *Perfum. essent. Oil Rec.*, 1937, 28, 412; Rakshit, *ibid.*, 1938, 29, 402).

The seeds (from Pretoria) on steam-distillation yield 1% of a colourless volatile oil (sp. gr. 1.05° , 0.953; $[\alpha]_D^{20}, +2.75^{\circ}$; $n^{24}, 1.511$) with a characteristic, somewhat anise-like odour; it contains no thymol (*Bull. imp. Inst., Lond.*, 1924, 22, 277).

The seeds of the plant are mucilaginous. They yield (8.0–11.6%) a fixed oil with semi-drying properties. The characteristics and fatty acid composition of seed oils from different localities vary (Table 2) (Tiwari, *Proc. nat. Acad. Sci. India*, 1941, 11, 45; Mehta & Mehta, *Curr. Sci.*, 1943, 12, 300; Shaikh & Patwardhan, *Proc. Indian Sci. Congr.*, 1956, pt III, 125).

The plant is used as a pot-herb. The fragrant leaves are used for flavouring sauces, soups and salads. The seeds of the plant have been used as food, in mixture with other grains, in times of scarcity. They are considered diuretic and tonic, and are used in the preparation of a cooling drink [Burkhill, II, 1574; Dalziel, 462; Gammie, *Rec. bot. Surv. India*, 1902, 2(2), 186; Rakshit, loc. cit.; Mehta & Mehta, loc. cit.].

TABLE I—YIELDS AND CHARACTERISTICS OF ESSENTIAL OILS OF *O. AMERICANUM* FROM DIFFERENT LOCALITIES IN INDIA

Yield, %	Jammu ¹	Ghazipur ²	Bangalore ³
	0.5	0.38	0.15–0.21
Sp. gr.	0.9105 (at 15°)	0.8914 (at 20°/20°)	0.9205–0.9249 (at 30°/30°)
[η] ⁴	..	-2.66°	+23.8° to +31.7°
"	1.4908 (at 20°)	1.4842 (at 20°)	1.4832–1.4865 (at 30°)
Acid val.	2.7	3.4	0.6–1.5
Ester val.	15.3	9.4	4.5–5.5
Sap. val. after acetylation	..	..	39.3–44.8
Solubility	sol. in 2 vol. of 80 alcohol	..	sol. in 0.5 vol. of 90% alcohol

¹ Handa *et al.*, *J. sci. industr. Res.*, 1957, **16A**(5), suppl., 19; ² Rakshit, *Perfum. essent. Oil Rev.*, 1938, **29**, 402; ³ Sanjiva Rao *et al.*, *ibid.*, 1937, **28**, 412.

TABLE 2—YIELDS AND CHARACTERISTICS OF FIXED OILS OF SEEDS OF *O. AMERICANUM* GROWN IN DIFFERENT STATES

	U.P. ¹	Gujarat ²	Maharashtra ³
Yield, %	11.6	10.0	8.0
Sp. gr.	0.9102 (at 26°)	0.9206 (at 30°)	0.9298 (at 27.7°)
"	1.4715 (at 25°)	1.4707 (at 40°)	1.4832 (at 29.5°)
Acid val.	8.6	72.15	6.2
Sap. val.	189.1	194.5	191.1
Iod. val.	93.8	179.8 (Hanus)	188.7 (Wij's)
Hehner val.	93.3	88.14	..
R. M. val.	..	0.6	1.54
Polenske val.	..	0.3	0.5
Acet. val.	nil	32.1	29.5
Unsapon. matter, %	0.48	1.25	2.25

Component fatty acids of oils: U.P.—palmitic, 20.5; stearic, 3.1; arachidic, 1.81; oleic, 62.9; linoleic, 4.5; and linolenic, 5.8%; Maharashtra—saturated acids, 6; α-linolenic, 13.5; isomeric linolenic, 6.8; α-linoleic, 9.5; isomeric linoleic, 51.5; and oleic, 12.7%.

¹ Tiwari, *Proc. nat. Acad. Sci. India*, 1941, **11**, 45; ² Mehta & Mehta, *Curr. Sci.*, 1943, **12**, 300; ³ Shaikh & Patwardhan, *Proc. Indian Sci. Congr.*, 1956, pt III, 125.

The plant possesses aromatic, carminative, diaphoretic and stimulant properties. A decoction of the plant is taken for coughs, that of leaves for dysentery; it is also used as a mouth wash for relieving toothache. The juice of leaves is given to children for cold, catarrh and bronchitis: a paste of leaves is used as an external application for parasitical skin affections. Fresh leaves are official in homoeopathy. Ether extracts of leaves show *in vitro* antibacterial activity against *Micrococcus pyogenes* var. *aureus* and *Escherichia coli*. The volatile oil from the whole plant inhibits the growth of tubercular bacilli in a dilution of 1:50,000; the leaf oil shows antibacterial activity against *Mycobacteria* (Nadkarni, I, 861; Burkhill, II, 1574; Dalziel, 462; Kirt. & Basu, III, 1960; Hoppe, 608; Joshi & Magar, *J. sci. industr. Res.*, 1952, **11B**, 261; Gupta & Viswanathan, *Antibiot. & Chemother.*, 1956, **6**, 194; Nickell, *Econ. Bot.*, 1959, **13**, 281).

***O. basilicum* Linn. SWEET BASIL, COMMON BASIL**
D.E.P., V, 440; Fl. Br. Ind., IV, 608; Mukerjee, *Rec. bot. Surv. India*, 1940, **14**(1), 18.

SANS.—*Munjariki, surasa, varvara*; HINDI—*Babui tulsi, gulal tulsi, kali tulsi, marua*; MAR.—*Marva, sabza*; GUJ.—*Damaro, nasabo, sabza*; TEL.—*Bhutulasi, rudrajada, vepudupachha*; TAM.—*Tirnirupachai, karpura tulasi*; KAN.—*Kama kasturi, sajjagida*; ORIYA—*Dhala tulasi, kapur kanti*.

OCIMUM

KASHMIR—*Niazbo*; PUNJAB—*Furrunj-mushk, baburi, niyazbo, panr.*

An erect, almost glabrous herb, 30–90 cm. high, native of Central Asia and North-West India, cultivated throughout the greater part of India. Leaves ovate-lanceolate, acuminate, toothed or entire, glabrous on both surfaces, glandular; flowers white or pale purple, in simple or much-branched racemes, often thyrsoid; nutlets ellipsoid, black, pitted.

The plant is very variable and its botanical nomenclature is complicated; several designations have often been assigned to one and the same type; polymorphism and cross-pollination under cultivation have given rise to a number of sub-species, varieties and races, differing in height, habit of growth, degree of hairiness, and colour of stems, leaves and flowers; and some types and forms have been confused with other species (Guenther, III, 399; Duthie, II, 235).

There are numerous varieties of *O. basilicum*. They are: var. *basilicum*, var. *pilosum* Benth., var. *majus* Benth., var. *diforme* Benth. (Curly-leaved Basil), var. *purpurascens* Benth. (Violet-red Basil), and var. *glabratum* Benth. (Common White Basil). Curly-

leafed basil is considered most suitable for cultivation; it is grown in France and is reported to give good yields of high quality oil (Mansfeld, 379; Heeger, 545; Parry, I, 259–60; Guenther, III, 400–01).

O. basilicum is propagated by seeds and is commonly grown in gardens as an aromatic herb. The best season for sowing in the plains of India is October–November and in the hills, March–April. Seedlings are raised in the nursery beds and transplanted 30 cm. apart in rows spaced 40 cm. apart. The crop is ready for harvest in 2½–3 months after planting; several cuttings may be made during the season. Plants are cut close to the ground, bunched and dried. Dried leaves and flowering tops are stripped from the stems and packed in closed containers. A yield of 6,800 kg. of leaves and flowers per hectare in two cuttings is reported from trial cultivations in Kanpur (Gollan, 16; Lowman, *Fmrs' Bull. U.S. Dep. Agric.*, No. 1977, 1946, 10; *Bull. Minist. Agric., Lond.*, No. 76, 1951, 16; Menon, 25).

Sweet basil possesses a clove-like scent with an aromatic, somewhat saline taste. It yields a volatile oil (Oil of Basil) used as a flavouring agent and also as perfume. The characteristics and composition of oil from different regions vary. Four types of oil are recognized: (i) European type, distilled from *O. basilicum* grown in Europe and America and commonly known as Oil of Sweet Basil; it contains methyl chavicol as the principal constituent, and linalool, but no camphor; it is highly prized for its fine odour; (ii) Reunion type, distilled originally in Reunion Island, but now produced in Comoro, Malagasy (Madagascar) and Seychelles Islands from plants of doubtful nomenclature; the oil contains methyl chavicol and camphor, but no linalool; it possesses a camphoraceous by-note and is considered inferior to the European oil; (iii) Methyl cinnamate type, distilled in Bulgaria, Sicily, Egypt, India and Haiti; it contains methyl chavicol, linalool and a substantial amount of methyl cinnamate; and (iv) Eugenol type, distilled in Java, Seychelles, Samoa and U.S.S.R.; it contains eugenol as the main constituent (Muenscher & Rice, 121; Parry, J. W., 1962, 210; Guenther, III, 399–414).

The characteristics and composition of Indian basil oil from five different centres are given in Table 3. A sample of oil distilled from plants grown in Chalakudi (Kerala) had a fine lavender odour and was rich in linalool and methyl cinnamate. Another sample obtained from plants grown at the H.B. Technologi-



FIG. 33—OCIMUM BASILICUM—FLOWERING BRANCH

cal Institute, Kanpur, contained methyl cinnamate, linalool, methyl chavicol and ocimene (Menon, 24-25; Dhingra *et al.*, *Indian Soap J.*, 1953-54, 19, 251).

Oil of basil (European type) is extensively used as a flavouring for confectionery, baked goods, sauces, catsups, tomato pastes, pickles, fancy vinegars, spiced meats, sausages and beverages. It is used also for scenting dental and oral preparations and in certain perfume compounds, notably jasmine blends, to impart strength and smoothness. Reunion oil also finds similar uses; it is preferred to the European type for use in soap perfumes. Methyl cinnamate and eugenol types have not attained commercial importance (Guenther, III, 403, 410; Hill, 463; Naves, *Perfum. essent. Oil Rec.*, 1950, 41, 286).

Basil oil possesses insecticidal and insect repellent properties; it is effective against houseflies and mosquitoes. It is also bactericidal (Rideal Walker efficient against *Salmonella typhosa*, 12) [Chopra *et al.*, *J. Malar. Inst. India*, 1941, 4, 109; Handa *et al.*, *J. sci. industr. Res.*, 1957, 16A(5), suppl., 18; *Chem.*

Abstr., 1952, 46, 4728; Khorana & Vangikar, *Indian J. Pharm.*, 1950, 12, 132].

The seeds of the plant are odourless with an oily, slightly pungent taste. When steeped in water, they liberate a mucilage which is semi-transparent and nearly tasteless. The mucilage (9.3%) yields on hydrolysis uronic acid, glucose, xylose and rhamnose. The seeds contain a drying oil with the following fatty acid composition: palmitic, 7.0; stearic, 0.2; oleic, 11.0; linoleic, 60.0; and linolenic, 21%. The unsaponifiable fraction is reported to contain β -sitosterol, oleonolic acid and ursolic acid. Aqueous extracts of seeds are active against Gram-positive bacteria and mycobacteria. Alcoholic extracts inhibit the coagulase activity of *Micrococcus pyogenes* var. *aureus* (Burkhill, II, 1573; Hilditch, 1956, 173; Shaikh & Patwardhan, *Proc. Indian Sci. Congr.*, 1957, pt III, 126; Nicholas, *J. Amer. pharm. Ass., sci. Edn*, 1958, 47, 731; Nickell, *Econ. Bot.*, 1959, 13, 281; Bhat & Broker, *J. sci. industr. Res.*, 1953, 12B, 540).

The plant is considered stomachic, anthelmintic, alexipharmac, antipyretic, diaphoretic, expectorant,

TABLE 3—YIELDS AND CHARACTERISTICS OF ESSENTIAL OILS OF *O. BASILICUM* FROM DIFFERENT LOCALITIES IN INDIA

	Delhi [†]	Ghazipur [‡]	Bombay [§]	Kanpur [¶]		Jammu||	
	leaves & soft stems	leaves & flowering tops	flowering plants	leaves [‡]	flowers	leaves & flowering tops	whole plant @
Yield, %	0.5 (av.)	0.4 (av.)	0.35	0.16-0.34	0.31-0.54	0.53	0.44
Sp. gr.	0.9942 (at 22°)	0.9666 (at 20°/20°)	1.004 (at 15°)	1.032 (at 24°)	0.9676-1.0040 (at 24°)	0.9718-1.0250 (at 24°)	0.9640 (at 15°)
$n^{20\circ}$	1.5275 (at 21°)	1.5122	1.3410	1.5405	1.513-1.527	1.5130-1.5280	1.5050
$[\alpha]_D$	-11°	-4.9°	-4.2°	-3.0°	-5° to -6.8°	-4.6° to -6.6°	..
Acid val.	11.1	2.0	1.1	1.2	0.6-2.2	0.3-5.8	0.7
Ester val.	..	178.7	197.9	241.3	..	..	21.9
Ester val. after acetyl- lation	..	259.2	249.5	274.1	..	..	..
Ester (as methyl cinnamate), %	56.7	52	57.1	69.7	43.6-63.6	47.7-74.3	3.6 (linalyl acetate)
Alcohol (as linalool), %	4.4	45	20.6	11.3	12.0-33.8	8.6-28.5	17.7
							69.4

[†] Nigam & Dutt, *Indian Soap J.*, 1945-46, 11, 210; [‡] Rakshit, *Perfum. essent. Oil Rec.*, 1938, 29, 89; [§] Khorana & Vangikar, *Indian J. Pharm.*, 1950, 12, 132; [¶] Dhingra *et al.*, *Indian Soap J.*, 1953-54, 19, 251; ^{||} Handa *et al.*, *J. sci. industr. Res.*, 1957, 16A(5), suppl., 18.

† Terpinene, 20.8%; ‡ methyl chavicol, 10.2-24.3%; ocimene, 0.8-4.5%. @ Grown from seeds imported from France.

OCIMUM

carminative, stimulant and pectoral. An infusion of the plant is given for cephalgia and gouty joints, and used as a gargle for foul breath. The juice of the leaves has a slightly narcotic effect and allays irritation in the throat. It is used as a nasal douche and as a nostrum for earache and also for ringworm. The plant is used in homoeopathic medicine. Roots, bark and leaves are cyanogenetic. Alcoholic extracts of leaves and alcoholic and aqueous extracts of flowers possess antibacterial activity against *Micrococcus pyogenes* var. *aureus*. Seeds possess demulcent, stimulant, diuretic, diaphoretic and cooling properties; they are given internally in cases of habitual constipation and piles. They are used in poultices for sores and sinuses (Kirt. & Basu, III, 1961-62; Kanny Lall Dey, 208; Burkill, II, 1572; Hoppe, 607; Quisumbing, 1046; Kurup, *J. sci. industr. Res.*, 1956, 15C, 153).

O. basilicum Linn. sub sp. **minimum** Danert syn.
O. minimum Linn.

Fl. Br. Ind., IV, 609; Mansfeld, 380.

A very small, compact, bush-like herb found all over India. It resembles sweet basil but is smaller in all parts. It may be grown as a border plant in gardens.

The plant is used like sweet basil. A volatile oil with a spicy odour is obtained from the herb by steam-distillation. It has the following characteristics: sp. gr.^{15°}, 0.9102; [α]_D, -12°; acid val., 5.3; ester val., 12.5; phenol content, 14%; sol. in 2 vol. of 70% alcohol, opalescent in 10 vol. It contains eugenol and linalool; a flavonoid, esdragol (4-methoxyl 1-allyl benzene), has been identified. The oil resembles French sweet basil oil in analytical constants, but differs in odour and chemical composition (Muenscher & Ricc, 122; Guenther, III, 431; Geissman & Hinreiner, *Bot. Rev.*, 1952, 18, 82; Heilbron & Bunbury, II, 483).

O. gratissimum Linn. **SHRUBBY BASIL**

D.E.P., V, 443; Fl. Br. Ind., IV, 608; Mukerjee, *Rec. bot. Surv. India*, 1940, 14(1), 20; Kirt. & Basu, Pl. 749B.

HINDI & BENG.—*Ban tulsi, ram tulsi*; MAR.—*Rama tulsi, rana tulasi*; GUJ.—*Avachibavachi, ram tulsi*; TEL. & KAN.—*Nimma tulasi, rama tulasi*; TAM.—*Elumicham tulasi, perum tulasi*; MAL.—*Kattu trittavu, rama tulasi*.

PUNJAB—*Banjere*.

A tall, much-branched perennial shrub, 1-2.5 m. high, found almost throughout India and in

Laccadive Islands. It is often cultivated. Leaves ovate, coarsely crenate-serrate, gland-dotted, pubescent on both surfaces; flowers pale greenish yellow, in simple or branched racemes, moderately close whorled; nutlets sub-globose, rugose, brown, with glandular depression, not mucilaginous when wetted.

O. gratissimum is more strongly scented than other species of the genus. It is mosquito repellent and its cultivation is recommended as a means of controlling measure for this pest. The characteristics and composition of the volatile oil obtained from plants growing in different areas vary. Two types of oil may be distinguished, one containing thymol as the chief constituent and the other eugenol. The former is obtained from plants grown in Ivory Coast and Central Africa; the latter type of oil is obtained from plants grown in Seychelles. A sample of oil distilled from plants reported to be *O. gratissimum* and grown in Delhi contained a high percentage of citral, but the identity of the plant is doubtful; the oil had the following characteristics: sp. gr.^{26°}, 0.8890; [α]_D, 0; n^{26°}, 1.4965; acid val., 12.2; sap. val., 37.5; and sap. val. after acetylation, 175.3. The oil contained: citral, 66.6; geraniol, 25.7; citronellol, 2.8; geranyl acetate, 1.5; and sesquiterpenes, 2.4%. A new sesquiterpene alcohol named gratissimol ($C_{15}H_{30}O_2$) has recently been identified in the oil. *O. gratissimum* grown at Bangalore, from seeds imported from U.S.S.R., gave 0.27% of a dark brown oil with the odour of cloves; it had the following characteristics: sp. gr.^{23°}, 0.9395; [α]_D, -18.1°; n^{23°}, 1.5132; sap. val., 15.71; and sap. val. after acetylation, 124.8. It contained: eugenol, 61.8%; ocimene, 1.5%; and an unidentified alcohol, 10% (Chopra, 1958, 580; Guenther, III, 424-27; Nigam & Dutt, *Indian Soap J.*, 1944-45, 10, 19; Nigam & Kumari, *Perfum. essent. Oil Rec.*, 1962, 53, 529; *Soap Perfum. Cosm.*, 1946, 19, 285; Nayak & Guha, *J. Indian chem. Soc.*, 1952, 29, 203).

Oil of *O. gratissimum* possesses marked antibacterial activity and low toxicity and irritability. It inhibits *in vitro* growth of *Mycobacterium tuberculosis*, *Micrococcus pyogenes* var. *aureus*, *Streptococcus pyogenes*, *Escherichia coli* and *Salmonella typhosa*. In 1:100 dilution, the oil acts as a local anaesthetic and is useful as an external application for inflamed joints and other chronic inflammatory conditions; in a concentration of 10 µg./cc., it relaxes intestinal and uterine musculature in experimental animals. The oil is used for the relief of earache,

toothache and abdominal colic in children (Sirsi et al., *J. Indian Inst. Sci.*, 1952, **34A**, 261).

The plant is considered digestive, tonic, stimulant, demulcent, diuretic, antiemetic, antiseptic and styptic. It is used in cough mixtures in combination with other expectorants. The leaf juice is given in stomach ache. The seeds of the plant are sometimes eaten. They are given in headache, neuralgia and dysentery. An infusion of the seeds is used in urinary disorders (Kirt. & Basu, III, 1965; Nadkarni, I, 864; Chopra, 1958, 598; Phatak & Oza, *J. Bombay nat. Hist. Soc.*, 1958, **55**, 532).

O. kilimandscharicum Guerke CAMPHOR BASIL
Fl. Trop. Africa, V, 340.

HINDI—*Kapur tulsi*; BENG.—*Karpur tulsi*.

An undershrub with pubescent branchlets, native of Kenya (East Africa), introduced and cultivated in India. Leaves ovate or oblong, acute, narrow at base, deeply serrated, pubescent on both surfaces; flowers in 4-6-flowered whorls on long villose racemes; nutlets ovoid to ovoid-oblong, black to brown.

O. kilimandscharicum is readily propagated from seeds and it can be grown on a wide variety of soils under irrigated and non-irrigated conditions. The plant has attracted attention as a source of camphor and during World War II, attempts were made in Sudan and a few other countries to extract camphor from it. In India also, experimental cultivation was undertaken in various areas and encouraging results were reported from Uttar Pradesh, W. Bengal, Maharashtra, Mysore, Madras, Kerala and Jammu. It does not do well in the plains of W. Bengal, but on the lower hills of Darjeeling, it thrives luxuriously; it is now grown successfully in Rongo hills and at Sukna (Kalinpong Forest Division, W. Bengal) (Het Singh et al., *Indian J. Pharm.*, 1955, **17**, 97; Deogun, *Indian For.*, 1950, **76**, 139; Biswas, 74; Chakravarti et al., *Bull. Calcutta Sch. trop. Med.*, 1959, **7**, 103; Choudhury, *Sci. & Cult.*, 1953-54, **19**, 354; Ribeiro, *J. sci. industr Res.*, 1950, **9B**, 281; Nayak & Guha, *J. Indian chem. Soc.*, 1952, **29**, 112; Krishnamurthi, 182; Mudaliar, *Indian Soap J.*, 1955-56, **21**, 206; Nair & Varier, ibid., 1952-53, **18**, 53; Handa et al., *Indian J. agric. Sci.*, 1953, **23**, 149).

O. kilimandscharicum grows in plains as well as on hills up to an elevation of 900 m. Once established, it thrives as a perennial, and can be coppiced for a number of years. The plant can stand fairly high temperatures, provided it gets sufficient moisture; it cannot withstand low temperatures below 30°F. It



FIG. 34—OCIMUM KILIMANDSCHARICUM—FLOWERING BRANCH

does well in areas with an annual rainfall of c. 125 cm. but can do with even less, provided the rain is evenly distributed or the water table is high. It grows on all types of soils but prefers clayey soil. Heavy soils with impeded drainage, such as that found in the Terai in U.P., are best suited for its cultivation. The plant is not grazed or browsed by cattle, sheep and goats. Because of its efficient root system and perennial habit, it prevents soil erosion in areas where it is grown (Deogun, loc. cit.; Krishnamurthi, 182).

The plant can be propagated by seeds and cuttings. Seeds are sown in nursery beds after the middle of March; 70-140 g. of seeds supply enough seedlings to plant a hectare or more. Seedlings, when 5-7 weeks old, are transplanted in the field at the break of monsoon or earlier if irrigation is available. Generally, no manuring is done, but addition of manure favours high leaf yield and application of farmyard manure, compost, ammonium sulphate or manure mixtures is recommended. Organic manure may be added before planting and chemical manure 3-4

weeks before the plants reach the flowering stage [Deogun, loc. cit. ; Kannan, *Indian Fmg.*, N.S., 1961-62, 11(2), 16].

For vegetative propagation, cuttings (c. 20 cm long) are taken from full grown plants and planted in nursery beds. They begin to sprout in 7-10 days and are ready for transplanting in 4-5 weeks. Leaves can be collected earlier from plants propagated by cuttings than from those raised from seeds. Propagation by cuttings is well adapted for multiplying plants which are likely to give high leaf yields (Kannan, loc. cit.).

The crop is ready for harvesting in 4-6 months after planting. Three cuttings are made in a year from plantations raised in the plains, in August-September, November-December and March-April ; the first cutting is done when the plants are c. 60 cm. high and have just started flowering and the lower leaves have begun to turn yellow. In cooler localities, where the plant is grown as an annual, only two cuttings are made, the first 2-3 months after planting and the second, at the end of the growing season or before frost. Plants are cut 5.0-7.5 cm. above the ground and cuttings collected in heaps. When the leaves have withered and dried they are thrashed out and stored in bags or heaped under sheds. Stems stripped of leaves are utilized as fuel for the distillation of oil. Leaves can be stored for a year or so without loss of camphor. A yield of 2,200 kg. of dry leaves per hectare per year has been obtained in Dehra Dun. An average yield of 5,500 kg. of dry leaves per hectare has been reported in three cuttings (Deogun, loc. cit. ; Kannan, loc. cit.).

The yields of oil and camphor vary according to the locality, season of harvest and the plant material distilled. Leaves contain the maximum amount of camphor and oil, followed by flowers ; stems contain only minute quantities. Leaves from transplanted plants give higher yields of oil than those of plants raised from field-sown seeds ; prior drying of leaves increases the yield of oil ; better yields are obtained during dry months. The yields of oil and camphor from plants experimentally grown at different places in India are given in Table 4 (Ribeiro, loc. cit. ; Dhingra *et al.*, *Indian Soap J.*, 1951-52, 17, 85 ; *Rep. essent. Oils Schimmel*, 1945, 32).

Oil distilled from *O. kilimandscharicum* is light yellow in colour, with a strong odour of camphor. The camphor content varies in different samples from 61 to 80.5%. Analysis of an oil from Bangalore gave the following values: *d*-camphor, 70 ;

d-*a*-pinene, 10.0 ; *d*-limonene, 6.0 ; terpinolene, 5.0 ; and unidentified sesquiterpenes and sesquiterpene alcohols, 9% ; eugenol is reported to be present in some samples but the sample from Bangalore contained no eugenol. Linalool, safrole and methyl cinnamate are absent. Oil distilled in Congo contained cineol, coriandrol and chavibetol. The high boiling fraction may contain a mixture of caryophyllenes ; this has not been confirmed. The oil possesses antibacterial properties similar to those of the oil of *O. gratissimum* though to a lesser degree (Nayak & Guha, *J. Indian chem. Soc.*, 1952, 29, 112 ; Choudhury, *Indian For.*, 1958, 84, 577 ; Dhingra *et al.*, loc. cit. ; *Rep. essent. Oils Schimmel*, 1949-50, 18 ; Chowdhury, *Perfum. essent. Oil Rec.*, 1959, 50, 28 ; Sirsi *et al.*, *J. Indian Inst. Sci.*, 1952, 34A, 261).

Extraction of camphor—Camphor is obtained from air-dried leaves by boiling with water in an earthen or metallic vessel (*degchi*) covered at the top with another vessel of the same size, the joint between the two vessels being made air-tight by clay or dough. The upper vessel is kept cool by covering with a wet cloth which is frequently changed. Fire is damped soon after the water starts boiling. The steam carries camphor and oil from the leaves and the former is deposited on the inside of the cooled upper vessel. The bottom vessel is recharged with leaves and the operation repeated. After a few more charges, the hot vessel is taken out and camphor scraped off. The oil is not recovered by this process (Deogun, loc. cit.).

Steam-distillation of leaves for the recovery of camphor is carried out in stills provided with condensers specially designed to obviate the risk of their being blocked by camphor-deposition. The leaves are charged into the still and steam-distilled. Besides the camphor, the oil is also recovered from the distillate. Camphor is separated from the oil by chilling and centrifuging, and purified by sublimation (loss on sublimation, c. 5%). The purified crystals (m.p. 174-75°) possess the characteristic odour and taste of natural camphor (from *Cinnamomum camphora*) and form a translucent mass when pressed (Dhingra *et al.*, loc. cit.).

Analysis of the seeds (dry) of *O. kilimandscharicum* gave the following values: moisture, 6.4 ; crude protein, 18.8 ; carbohydrates, 23.8 ; ether extr., 17.4 ; crude fibre, 27.0 ; and ash, 6.5%. The seed oil (yield, 12.5%) is pale yellow and has the following characteristics: n^{25} , 1.4852, n^{40} , 1.4795 ; iod. val., 192.6 ; sap. val., 292.0 ; free fatty acids (as oleic), 1.2% ; and un-

TABLE 4—YIELDS AND CHARACTERISTICS OF ESSENTIAL OILS FROM *O. KILIMANDSCHARICUM* GROWN IN DIFFERENT LOCALITIES IN INDIA

Yield, % (of dried material)	Partly decamphorized by chilling			Total distillate			
	Kanpur ¹	Trivandrum ²	Jammu ³	Bangalore ⁴	Sukna ⁵	Mahatpur ⁶	Mysore ⁶
	3.0-4.8	3.8	2.27	3.3	4.00-5.46	2.56-3.17	1.1-2.2
Sp. gr.	0.9209 (at 20°)	0.9180 (at 25°)	0.9387 (at 30°)	0.9004 (at 30°)	0.9680 (at 30°)	0.923 (at 33°)	0.9215 (at 29.5°)
[α] _D	+30.17°	+28.23°	..	..	+34.6°	+37.3°	+27.6°
n	1.4745	1.4750	1.4725 (at 30°)	1.470 (at 30°)	1.4761 (at 26°)	1.4610 (at 34°)	1.4715 (at 30°)
Acid val.	1.22	0.22	3.7	1.2	..	1.12	1.16
Ester val.	12.65	8.55	..	..	..	6.9	11.3
Ester val. after acety- lation	75.7	27.3	..	..	..	..	..
Ketones (as camphor), %	39.47 (52-60)†	36.6 (62.13)†	39.33	40.5 (70.5)†	70	80.50	61.66
Phenols (as eugenol), %	nil	nil	..	1.66	nil	..	14
Solubility	freely sol. in 80% alc.	freely sol. in 80% alc.	..	freely sol. in 90% alc.	..	sol. in 1.4 vol. of 70% alc.	sol. in 2 vol. of 70% alc.
						insol. in 70% alc., sol. in 85% alc. in all propor- tions	

¹ Dhingra *et al.*, Indian Soap J., 1951-52, **17**, 85; ² Nair & Varier, ibid., 1952-53, **18**, 53; ³ Het Singh *et al.*, Indian J. Pharm., 1955, **17**, 97; ⁴ Nayak & Guha, J. Indian chem. Soc., 1952, **29**, 112; ⁵ Choudhury, Indian For., 1958, **84**, 577; ⁶ Ramaswamy *et al.*, ibid., 1951, **77**, 612.

† Figures within brackets indicate camphor content of the total distillate.

sapon. matter, 0.4%. The component fatty acids of the oil are: palmitic, 8.2; arachidic, 5.3; oleic, 5.3; linoleic, 12.5; octadecadienoic (conjugated), 3.7; linolenic, 64.5; and octadecatrienoic, 0.5%. For use in paints, the seed oil is superior to linseed oil: the film obtained is hard with a bright finish (Barker *et al.*, J. Soc. chem. Ind., Lond., 1950, **69**, 71T; Henry & Grindley, ibid., 1944, **63**, 188).

O. kilimandscharicum is a primary source of camphor but its exploitation, however, is considered uneconomical unless the oil, obtained as a by-product also finds a commercial outlet. Oil which has been partially decamphorized possesses insecticidal properties and may be used as a mosquito repellent; it is one-third as effective as pyrethrum extract; it may be used also as a solvent for DDT. The low boiling fraction of the oil may be used as a solvent and vehicle for metallic lustres on ceramic bodies (Chowdhri & Haksar, Indian Oil & Soap J., 1961-62,

27, 187; Dhingra, 43; Chow *et al.*, Indian J. Malariaiol., 1951, **5**, 187; For. Res. India, 1952-53, pt I, 12).

O. sanctum Linn. SACRED BASIL, HOLY BASIL

D.E.P., V, 443; Fl. Br. Ind., IV, 609; Mukerjee, Rec. bot. Surv. India, 1940, **14**(1), 19.

SANS.—*Ajaka, brinda, manjari, parnasa, patrapuspha, suvasa tulasi*; HINDI—*Tulsi, baranda, kala tulsi*; BENG.—*Tulsi*; MAR.—*Tulasa, tulasi chajadha*; GUJ.—*Tulsi*; TEL.—*Tulasi, brynda, gaggera, krishna tulasi, nalla tulasi*; TAM.—*Thulasi*; KAN.—*Vishnu tulasi, kari tulasi, sri tulasi*; MAL.—*Trittavu*.

MUNDARI—Tunrusi.

An erect, herbaceous, much-branched, softly hairy annual, 30-75 cm. high, found throughout India ascending up to 1,800 m. in the Himalayas, and in Andaman and Nicobar Islands. Leaves elliptic-oblong, acute or obtuse, entire or serrate, pubescent

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on both sides, minutely gland-dotted; flowers purplish or crimson, in racemes, close whorled; nutlets sub-globose or broadly ellipsoid, slightly compressed, nearly smooth, pale brown or reddish, with small black markings.

O. sanctum is commonly cultivated in gardens; it is frequently found as an escape. The plant is held sacred by Hindus all over India and frequently grown in courtyards and temples. At least two types of *O. sanctum* are met with in cultivation: the green type (*Sri tulsi*) is the most common; the second type (*Krishna tulsi*) bears purple leaves. The plant is propagated by seeds. It is susceptible to powdery mildew (*Oidium* sp.), seedling blight (*Rhizoctonia solani* Kuhn.) and root-rot [*Rhizoctonia bataticola* (Taub.) Butler] [Gupta et al., *Indian med. Gaz.*, 1942, **77**, 210; Rakshit, *Sci. & Cult.*, 1939-40, **5**, 108; Mahmud, ibid., 1950-51, **16**, 115, 161; Deshmukh & Mahmud, *Nagpur agric. Coll. Mag.*, 1950-51, **25**(1 & 2), 3].

The leaves on steam-distillation yield a bright yellow volatile oil possessing a pleasant odour characteristic of the plant with an appreciable note of cloves. The yield of oil varies with type, season and the place of origin. The yields and characteristics of the oils distilled from leaves and flowering

tops of plants grown in Ghazipur (2 types) and Jammu were as follows: *Ghazipur*-type *Krishna tulsi* (yield of oil, 0.1-0.23%): sp. gr., 0.9421-1.0280; acid val., 1.1-1.6; phenols, 45-76%; and aldehydes, 15-25%; type *Sri tulsi* (yield of oil, 0.20-0.33%): sp. gr., 0.9255-1.1242; acid val., 1.0-2.4; phenols, 50-76%; and aldehydes, 10-15%; *Jammu* (yield of oil, 0.9%): sp. gr.¹⁵, 0.967; n_{D}^{20} , 1.5197; sap. val., 86; sol. in all proportions of 90% alcohol. A sample of oil from Allahabad gave on analysis: eugenol, 71%; eugenol methyl ether, 20%; and carvacrol, 3%. The oil distilled from plants growing in Philippines is reported to possess a sweet anise-like odour; it contains methyl chavicol, cineole and linalool (Menon, 26; Dutt, *Proc. Indian Acad. Sci.*, 1939, **9A**, 72; Rakshit, *Sci. & Cult.*, 1939-40, **5**, 108; Handa et al., *Indian J. agric. Sci.*, 1955, **25**, 73; Guenther, III, 432).

The oil is reported to possess antibacterial and insecticidal properties. It inhibits the *in vitro* growth of *Mycobacterium tuberculosis* and *Micrococcus pyogenes* var. *aureus*; in antitubercular activity, it has one-tenth the potency of streptomycin and one-fourth that of isoniazid. It has marked insecticidal activity against mosquitoes, though it is not comparable to that of pyrethrum; the mosquito repellent action lasts for c. 2 hr. The oil from the green type is active against *Salmonella typhosa*; it has a Rideal Walker (R.W.) co-efficient of 6, while the R.W. coefficient of the oil from red type is 3. Ether and alcohol extracts of leaves are active against *Escherichia coli* (Gupta & Viswanathan, *Antibiot. & Chemother.*, 1955, **5**, 22; Gupta et al., *Indian med. Gaz.*, 1942, **77**, 210; Chopra et al., *J. Malar. Inst. India*, 1941, **4**, 109; Joshi & Magar, *J. sci. industr. Res.*, 1952, **11B**, 261; George et al., ibid., 1947, **6B**, 42).

The seeds of plant give a greenish yellow fixed oil (17.8%) with good drying properties. It has the following characteristics: sp. gr.²⁰, 0.9063; n_{D}^{20} , 1.4789; acid val., 2.0; sap. val., 181.6; iod. val., 173.0; thiocyanogen val., 104.6; acet. val., 12.1; R.M. val., 1.2; Polenske val., 0.2; Hehner val., 93.6; and unsaponifiable matter (contains sitosterol), 2.3%. The fatty acid composition of the oil is as follows: palmitic, 6.9; stearic, 2.1; oleic, 9.0; linoleic, 66.1; and linolenic, 15.7%. The seeds contain a mucilage (hexouronic acid, 27.2; pentoses, 38.9; and ash, 0.2%) which on hydrolysis yields xylose and an acid polysaccharide; the latter is possibly composed of xylose and glucuronic acid in 2:1 molar ratio (Nadkarni & Patwardhan, *Curr. Sci.*, 1952, **21**, 68; Ingle & Bhade, *Proc. Indian Sci. Congr.*, 1952, pt III, 110).



FIG. 35—OCIMUM SANCTUM—FLOWERING BRANCH

The plant is used as a pot-herb; leaves are used as condiment in salads and other foods. It is also reputed to have medicinal properties. Besides the volatile oil, the plant is reported to contain alkaloids, glycosides, saponins and tannins. The leaves contain ascorbic acid (83 mg./100 g.) and carotene (2.5 mg./100 g.) (Uphof, 251; *Chem. Abstr.*, 1954, **48**, 11728; Basu *et al.*, *J. Indian chem. Soc.*, 1947, **24**, 358).

The juice of leaves possesses diaphoretic, antiperiodic, stimulating and expectorant properties; it is used in catarrh and bronchitis, applied to the skin in ringworm and other cutaneous diseases and dropped into the ear to relieve earache. An infusion of the leaves is used as a stomachic in gastric disorders of children. A decoction of the root is given as a diaphoretic in malarial fevers. The seeds are mucilaginous and demulcent, and are given in disorders of genito-urinary system. They contain antistaphylocoagulase which can be extracted with water and alcohol (Kirt. & Basu, III, 1966-67; Bhat & Broker, *J. sci. industr. Res.*, 1954, **13B**, 305).

O. viride Willd. FEVER PLANT OF SIERRA LEONE

Chittenden, III, 1392; Irvine, 1961, 766.

A branched shrub, up to 1.8 m. high, native of Africa and introduced into India. Leaves ovate or obovate, acuminate, margin toothed; flowers cream-white or yellowish, in paniculate racemes.

The plant is highly scented. The leaves of the plant are used as a flavouring agent in cooking and in salads. The plant yields on steam-distillation a volatile oil (0.4-2.6%) with a characteristic odour of thymol and a pungent, spicy taste. A sample of oil from Grasse (France) had the following constants: sp. gr.^{15°}, 0.9104; $|\alpha|_{D}^{20}$, +0.9°; n^{25} , 1.4962; ester (as linalyl acetate), 2%; combined alcohol, 1.5%; free alcohol, 31%; phenol, 38%; sol. in 1.5 vol. of 80% alcohol. The principal constituent is thymol (total phenols, 18-65%); *d*-limonene, α - and γ -terpinene, and possibly dipentene and terpineol are present. The oil has antiseptic properties: it repels mosquitoes (Burkill, II, 1576; Cobley, 336; Dalziel, 463; Guenther, III, 429; *Bull. imp. Inst., Lond.*, 1908, **6**, 209).

The seeds contain 9.7% of a drying oil with the following characteristics: n^{25} , 1.4808, n^{40} , 1.4732; iod. val., 168.9; sap. val., 292.1; free fatty acids (as oleic), 8.0%; and unsapon. matter, 1.1%; component fatty acids: palmitic, 8.7; stearic, 2.7; arachidic, 2.6; oleic, 14.3; linoleic, 31.7; octadecadienoic (con-

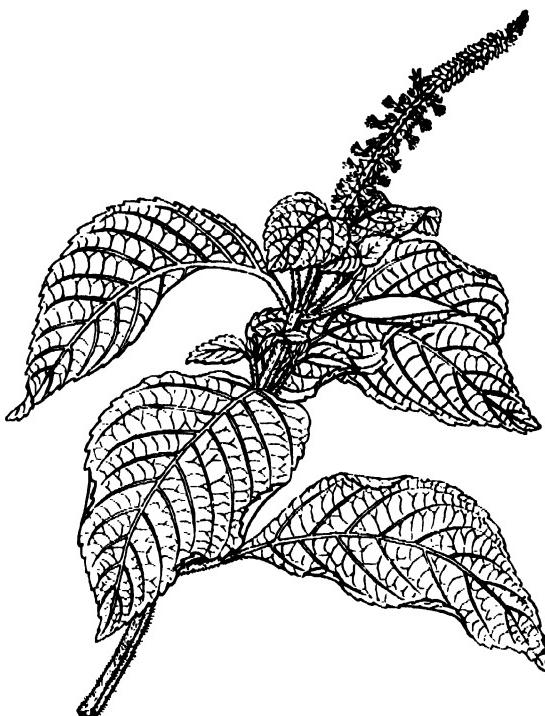


FIG. 36—*OCIMUM VIRIDE*—FLOWERING BRANCH

jugated), 0.8; and linolenic, 39.2% (Barker *et al.*, *J. Soc. chem. Ind., Lond.*, 1950, **69**, 71T).

The plant is used as a poultice for rheumatism and lumbago: a pomade containing pulped leaves and shea butter (from *Butyrospermum parkii* Kotschy) is applied to itch. A decoction of the leaves is used in fevers and coughs. The juice of leaves is used for catarrh and as eye drops for conjunctivitis (Irvine, 1961, 766-67; Dalziel, 462-63).

Octopus — see *Molluscs*

Odina — see *Lannea*

ODONTITES Zinn (*Scrophulariaceae*)

Fl. Br. Ind., IV, 305.

A genus of annual herbs found in South America, Europe, North Africa and extending to Central Asia. Two species occur in India.

O. serotina (Lam.) Dum. syn. *Bartsia odontites* Hook. f. (*Fl. Br. Ind.*); *Euphrasia odontites* Linn. is an erect or ascending annual, 15-45 cm. high, with lanceolate leaves and pink flowers found in Kashmir at altitudes of 2,100-2,400 m. The herb and seeds of the plant contain a glycoside, rhinanthin (Wehmer, II, 1124).

OENANTHE

OENANTHE Linn. (*Umbelliferae*)

A small genus of marsh or aquatic herbs distributed in northern hemisphere, S. Africa and tropical Australia. One or two species occur in India.

O. javanica (Blume) DC. syn. *O. stolonifera* Wall. ex DC.; *O. benghalensis* Benth. & Hook. f.; *O. linearis* Wall. ex DC.

Fl. Br. Ind., II, 696; Fl. Malesiana, Ser. I, 4(2), 136.
BENG.—*Pan-turasi*.

MUNDARI—*Ependung*.

A perennial stoloniferous herb, 60–120 cm. high, found in marshy places and on river banks in N. India from Kashmir to Assam, ascending to an altitude of 1,800 m. Leaves pinnate to bipinnate: segments lanceolate or rhomboid-lanceolate, serrate, sometimes lobed; flowers white, in compound umbels; fruit obovoid; seed terete. The plant is very variable as to the dimensions of various parts, compoundness of leaves, the length of peduncles, etc. Various forms classified formerly as separate species on the basis of these characters are connected by intermediate types [Buwalda, *Blumea*, 1936–37, 2, 196; Fl. Malesiana, Ser. I, 4(2), 136].

The plant is cultivated occasionally in Indo-China, Sumatra and Malay Peninsula. It is used as vegetable and eaten raw or steamed with rice; it is used also as a flavouring. The plant contains a flavonoid, persicarin. The fruit yields 1.5% of a pleasant smelling essential oil containing phellandrene and myristicin; substances with the odours of turpentine and safrole are also present [Burkill, II, 1578; Fl. Malesiana, Ser. I, 4(2), 136; *Chem. Abstr.*, 1957, 51, 5918; 1954, 48, 4777].

OENOTHERA Linn. (*Onagraceae*)

Fl. Br. Ind., II, 582; Bailey, 1949, 737.

A genus of herbs or undershrubs distributed chiefly in temperate America with some species occurring in the tropics. Some species have been introduced into Indian gardens, of which a few have run wild.

Commonly known as Evening-Primrose, species of *Oenothera* are prized for their saucer-shaped, white, yellow, pink or red flowers, many of which are fragrant. They are planted in borders, beds and rockeries. They can be easily propagated from seed or by cuttings. The plants do not stand transplanting well and are preferably sown at site (Bailey, 1947, II, 2328–29; Firminger, 517; Gopalaswamiengar, 448).

O. odorata Jacq. and *O. tetraptera* Cav. are herbs with vespertine flowers planted in gardens and also

met with as escapes. *O. odorata*, a native of Chile, is considered to be a useful cover crop in S. Australia affording protection against wind erosion. It is said to yield a pasture fairly rich in carbohydrates, but in New South Wales, the plant is suspected of poisoning pigs. *O. tetraptera* with large white blossoms is said to cause sickness and death amongst the dairy cows. The roots of both the species contain β -sitosterol (Fyson, I, 236; Hall, *J. Dep. Agric. S. Aust.*, 1958, 62, 113; Webb, *Bull. Coun. sci. industr. Res. Aust.*, No. 232, 1948, 122; *Chem. Abstr.*, 1956, 50, 533).

Oil Palm, African—see *Elaeis*

Oil Sardine—see **Fish and Fisheries Supplement**

Okra—see *Hibiscus*

OLAX Linn. (*Olaceaceae*)

A genus of trees, shrubs or undershrubs distributed in tropical Asia, Africa, Malagasy (Madagascar) and Australia. Eight species occur in India.

O. scandens Roxb.

D.E.P., V, 479; Fl. Br. Ind., I, 575; Kirt. & Basu, Pl. 232B.

HINDI—*Dheniani*; BENG.—*Koko-aru*; MAR.—*Harduli*; TEL.—*Kurpodur, murikimalle*; TAM.—*Kadalruchi, malliveppam*; KAN.—*Bapanamushtigida, karadu*; ORIYA—*Boderia, bodobodoria, badalia*.

SANTAL.—*Hund*; MUNDARI—*Rimilbiri, rimiljo, urmenedojo*.

A scandent thorny shrub found often in ravines and stream banks in the sub-Himalayan tract in Kumaun, upper Gangetic plain, Bihar, Orissa (Mayurbhanj), Madhya Pradesh, northern Circars, Carnatic, Deccan and western ghats. Bark grey, deeply cleft vertically; leaves ovate-oblong, entire; flowers small, white, in axillary racemes; fruit a globose or ovoid drupe, yellow, fleshy with an accrescent calyx.

This climber is considered very destructive to forest trees, because of its rank growth. Its leaves and young shoots are used as pot-herb or as a green vegetable. The fruit is edible and reported to be used for making sherbet. In Malaya, a decoction of the roots is given as a draught. The bark is used by Santals in anaemia during fevers. The wood (wt., 608.76 kg./cu.m.) is yellowish white, soft and porous and is not put to any industrial purpose (Gamble, 163; Bressers, 27; Burkill, II, 1578; Kirt. & Basu, I, 568).

O. acuminata Wall. ex Benth. (MIKIR—*Han-*

misang, han-boka, han-kanoj; GARO—*Bol-narang, moen*; KHASI—*Dieng-tilut, dieng-tyrul*) is a large shrub or small tree, 4.8 m. high, found in Bhutan and plains and hills of Assam at an altitude of 750 m. The Mikirs eat the leaves cooked, especially with fish and meat. Wood is cream coloured, tough and close-grained (Fl. Assam, I, 247).

O. imbricata Roxb. is a scandent shrub with ovoid fruits found in S. Andaman Islands; the fruits are edible (Parkinson, 125; Burkill, II, 1578).

O. nana Wall. ex Benth. (GUJ.—*Himi, shigroti, tadholi, sudio*; SANTAL.—*Merom-met*) is a small undershrub, 60 cm. high, with globose or ovoid fruit, deep yellow when ripe, found in the Himalayas, from Punjab to Sikkim at an altitude of 1,500 m., upper Gangetic plain, Chota Nagpur, North Bengal, plains and hills of Assam, northern Circar and Gujarat. The fruit of the plant, though insipid, is edible. It is used medicinally by Santals (Fl. Assam, I, 248; Kirt. & Basu, I, 569).

O. zeylanica Linn. is an erect shrub or a small tree with ovate-acuminate or ovate-lanceolate leaves, yellowish flowers and bright scarlet, ovoid drupes found in the Deccan Peninsula. The leaves of the plant are eaten as salad. Fried with red onions and ghee, leaves are eaten for frequent and painful micturition. The wood is yellowish white, hard, close- and even-grained, resembling boxwood (Lewis, 100; Chandrasena, 9-10; Gamble, 164).

Oldenlandia — see Hedyotis

OLEA Linn. (*Oleaceae*)

A genus of evergreen trees and shrubs distributed in the warm temperate and tropical regions of the Old World. About 6 species occur in India; *O. europaea* (Common Olive) has been introduced and experimentally grown in some parts of India.

O. dioica Roxb.

D.E.P., V, 484; Fl. Br. Ind., III, 612; Talbot, II, Fig. 390.

BENG.—*Atta-jam*; MAR.—*Karamba, parjamb, lauki*; TAM.—*Koli, payar, yedalei*; KAN.—*Hejjea-kerkal, akki*; MAL.—*Edana*.

NEPAL.—*Kalo kyamuna*; LEPCHA.—*Timburnyok*; ASSAM.—*Poreng, bonbholuka, chapu*.

A medium-sized mostly dioecious tree, usually 18 m. in height but sometimes reaching to 30 m., found in the eastern Himalayas, Duars, Assam and in Deccan Peninsula, chiefly in western ghats. Bark greyish brown; leaves very variable usually elliptic-

lanceolate; flowers in lax panicles, small, white; drupes ellipsoid, deep purple, 13-17 mm. long.

The tree is planted for shade. It has been reported to possess a fairly fast rate of growth with a mean annual girth increment of c. 3.19 cm.; recently the growth measurements in Kanara forests of Mysore have, however, indicated much slower (c. 1/3) rate of growth. It is attacked by a number of lorantheaceous parasites. *Cystospora oleae* Butler and *Stephanotheca oleae* Hansf. & Thirum. attack the leaves [Troup, II, 660; Mathauda, Indian For. Bull., N.S., No. 169, 1953, 8; Santapau, Rec. bot. Surv. India, 1953, 16(1), 164; Information from Forest Pathology Branch, F.R.I., Dehra Dun].

The wood has a sweet scent when freshly cut and is, therefore, known as Rose Sandalwood in Bombay. The sapwood is reddish grey; heartwood dark yellowish brown, streaked and mottled, straight- and close-grained, hard, strong, elastic and heavy (wt., 769-865 kg./cu. m.). The wood is used in Assam for domestic purposes; it is suitable also for carving and cabinet work (Talbot, II, 198; Bourdillon, 230; Fl. Assam, III, 238).

The fruit is bitter to taste. The bark is reported to be used as febrifuge; in Queensland, it is reputed to be an emetic. The leaves (nitrogen content, 1.14%) may be used as green manure (Kirt. & Basu, II, 1536; Webb, Bull. Coun. sci. industr. Res. Aust., No. 232, 1948, 121; Sonde, Arecan. Bull., 1955-56, 6, 78).

O. europaea Linn. COMMON OLIVE

D.E.P., V, 485; Bailey, 1947, II, 2333.

A small tree, native of western Asia, 8-10 m. high, is widely cultivated for its fruits which yield the Olive Oil of commerce. The tree is extensively grown in countries bordering the Mediterranean and has also been introduced into many other parts of the world. The tree is propagated by cuttings; grafting and budding of *O. europaea* on Indian olive, *O. ferruginea*, has proved successful. Attempts at cultivating *O. europaea* in different parts of India have not been successful so far. In many places the trees attain normal height but do not either bear fruit or if they do, the fruit does not mature. For proper growth the plant needs deep fertile soil and a temperature averaging to c. 13° not dropping to below -10°. Locations satisfying these requirements are found in Kashmir, Himachal Pradesh and Nilgiris (Madras State) and cultivation in these areas may prove successful. A few plants from Italy have been grown in Coonoor and are reported to be thriving well. Attempts are also

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being made to grow the trees in Himachal Pradesh (Hill, 200, 429; Firminger, 193; Troup, II, 661; Chopra *et al.*, *J. sci. industr. Res.*, 1949, 8A, 14; Hayes, 1957, 415; Information from Director of Agriculture, Madras, and Horticulturist, Himachal Pradesh).

The fruit is a one-seeded drupe, smooth, oblong or oval, 2-3 cm. long, greenish at first, but shiny purplish black when ripe; it is oily and when fresh, extremely bitter. Both green and ripe fruits are edible. Fresh fruit may be pickled, stuffed or made into various edible preparations. Olive oil is obtained from ripe fruit by expression; the yield ranges from 15 to 40%. If the fruit is not fully mature, the yield of oil is poor and its taste bitter. Olive oil is a non-drying oil varying in colour from pale yellow through greenish yellow to greenish brown. It is fluid and clear at ordinary temperatures and deposits stearine when cooled. Good grades of oil have a mild characteristic odour and a bland taste; inferior grades have a sharp unpleasant flavour. The characteristics of the oil are as follows: sp. gr.^{15°}, 0.9145-0.9190; n^{15°}, 1.4670-1.4675; sap. val., 188-96; iod. val., 78-86; thiocyanogen val., 79.4; unsapon. matter, 0.5-1.5%; and titre, 17-21°. The oil (from Spain) has the following fatty acid composition: myristic, 0.2; palmitic, 9.5; stearic, 1.4; arachidic, 0.2; oleic, 81.6; and linoleic, 7.0%. Squalene, phytosterol and tocopherol are present (Hayes, 1957, 415; Hill, 200, 428; Macmillan, 272; Eckey, 719-25; Bailey, 1951, 155; Williams, K.A., 391; Kirschenbauer, 175-76, 198).

Olive oil is used chiefly as a salad oil; it is used also in the manufacture of soaps, textile lubricants and sulphonated oils; the oil is demulcent, emollient and laxative. India's requirements of olive oil are met by imports, mainly from European countries. Imports during 1960-61 and 1961-62 were 58,110 and 44,329 kg. valued at Rs. 232,326 and 201,801 respectively (Eckey, 726; B.P.C., 1959, 509).

O. ferruginea Royle syn. *O. cuspidata* Wall. ex G. Don INDIAN OLIVE

D.E.P., V, 483; Fl. Br., Ind., III, 611.

N. W. HIMALAYAS—*Kahu, kan, kao*; GARHWAL—*Bairbanj*.

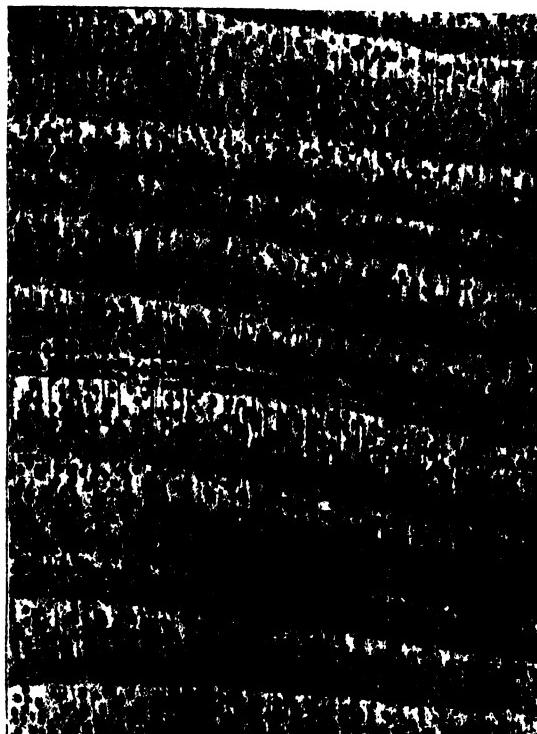
A medium-sized tree, up to 15 m. in height and 3.6 m. in girth, but usually much smaller, found in the Himalayas from Kashmir to Kumaun up to an altitude of 2,400 m.; it is occasionally cultivated in the plains of N. India. Bark grey, smooth, thin, exfoliating in narrow strips; leaves oblong-lanceolate,

cuspidate, coriaceous; flowers in trichotomous panicles, bisexual, whitish; drupes ovoid, 5-8 mm. long, black when ripe. This species is closely related to *O. europaea* and some authors consider it as a sub-species of the latter (Mansfeld, 349).

The tree is somewhat localized in distribution and occurs chiefly along the outer hills and in the inner dry valleys of western Himalayas. It is browsed by animals and browsed plants usually assume a dense shrubby form. The tree is a shade-bearer. It coppices well if cut in the dry season. Natural reproduction by seeds takes place in February. For artificial reproduction, seeds are sown towards the end of the cold season in pots or nursery beds and transplanting may be done during the rainy season of the following year, or in April, if irrigation is possible. The tree can be propagated also by mature cuttings and by root suckers. The rate of growth is slow and natural seedlings attain a height of c. 22 cm. in 3 years. Vigorous coppice shoots grow more rapidly (c. 60 cm./annum) for some years. Indian olive is attacked by *Sphaero-*



FIG. 37—OLEA FERRUGINEA—FLOWERING AND FRUITING BRANCHES



F.R.I., Dehra Dun. Photo : S. S. Ghosh
FIG. 38—OLEA FERRUGINEA—TRANSVERSE SECTION OF WOOD ($\times 10$)

trypes macmahoni Stebbing ; maggots of *Dacus oleae* var. *asiatica* Silvestri breed in fruits, while caterpillars of *Meridarchis reprobata* Meyrick feed on flowers. Dead and decaying stumps are subject to the attack of *Fomes fomentarius* (L. ex Fr.) Kickx (Troup, II, 659-60 ; Coventry, *Indian For.*, 1915, 41, 391 ; Stebbing, 494 ; Mathur *et al.*, *Indian For. Bull.*, N.S., No. 223, 1958, 64 ; Information from F.R.I., Dehra Dun).

The wood of Indian olive is much valued locally. Sapwood is whitish, heartwood light brown to olive-brown or deep purple ; lighter specimens are frequently striated with narrow dark bands. The wood is straight- or shallowly interlocked-grained, fine- and even-textured, with smooth oily feel, very strong, elastic, hard and heavy (sp. gr., c. 1.03 ; wt., c. 1057 kg./cu. m.). The wood seasons well if protected from hot winds and rapid drying ; wavy cracks develop when it is rapidly dried. Large logs should be converted as soon as possible after felling while smaller pieces can be seasoned in billet form. The wood is durable and resistant to fungal attack. It does not need antiseptic treatment. It is not difficult to

saw and turn and can be brought to a smooth surface which takes a beautiful polish. The timber is used chiefly for tool handles, walking sticks, combs, toys, turnery articles and carving. It is used also for ploughs, ginning machines and boat building. It is suitable for engraving and printing blocks and for mathematical instruments. Figured specimens of light shade are useful for veneers, panels and cabinet making (Pearson & Brown, II, 720-22 ; Chowdhury, *Indian For. Bull.*, N.S., No. 84, 1934, 62 ; Titmuss, 96 ; Trotter, 1944, 209 ; Anver, *Pakist. J. For.*, 1954, 4, 21 ; Coventry, loc. cit.).

The fruits of Indian olive are edible ; the pulp is scanty and is not particularly pleasant to taste. Both pulp and seeds yield oil (pulp, 31-32% and seeds, c. 15%) ; the entire fruit is used for the extraction of oil. The oil is greenish yellow or dark green in colour, with sweetish taste resembling that of sesame oil. The characteristics of the two oils are as follows: *pulp oil*—sp. gr.^{15°}, 0.920 ; sap. val., 190.9 ; iod. val., 93.6 ; and R.M. val., 0.6 ; *seed oil*—sp. gr.^{15°}, 0.913 ; *n^{25°}*, 1.4665 ; sap. val., 190.1 ; iod. val., 85.9 ; saturated acids, 9.8% ; and unsaturated acids, 84.5% [Krishna *et al.*, *Indian For. Rec.*, N.S., *Chem.*, 1936, 1(1), 23 ; Mensier, 400 ; Said, *Pakist. J. For.*, 1957, 7, 58].

The tree is lopped for fodder mainly for camels and goats. Leaves and bark are bitter and astringent and used as antiperiodic in fever and debility (*Jt. Publ. imp. agric. Bur.*, No. 10, 1947, 111).

O. glandulifera Wall. ex G. Don

D.E.P., V, 485 ; Fl. Br. Ind., III, 612 ; Fyson, II, 328.

N.W. HIMALAYAS—*Gulili, barkao, phalsh* ; KUMAUN—*Gair, galdu, garur* ; NILGIRIS—*Kunthay*.

A handsome, medium-sized to large tree, up to 27 m. in height and 3 m. in girth, found in the outer Himalayas from Kashmir to Nepal up to an altitude of 1,800 m., and in the hills of S. India ; it is usually found along banks of rivers and in shady ravines. Bark greyish brown, exfoliating in brittle scales ; leaves ovate- or oblong-lanceolate ; flowers in trichotomous panicles, bisexual, white ; drupes ellipsoid, oblique, 7-13 mm. long, purplish black when ripe.

The tree yields pinkish to reddish grey wood, which is hard, heavy (wt., c. 897 kg./ cu. m.) and durable ; it takes a good polish. It is used for house construction, carpentry, agricultural implements and turnery (Gamble, 475 ; Lewis, 273).

The bark and leaves are astringent and are used as

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antiperiodic in fevers. The bark is reported to contain a bitter glycoside, quercetin, a non-toxic alkaloid, and tannin. Leaves are lopped for fodder (Kirt. & Basu, II, 1535 ; Wehmer, II, 953).

A pale yellow manna-like substance exudes from incisions in the tree, reported to be caused by insects during periods of drought ; artificial incisions do not induce exudation. The exudation when freed from fibrous matter is completely soluble in hot water and contains D-mannitol (c. 95%), traces of a gelatinous substance, and reducing sugars (Sri Ram & Narasimha Rao, *Curr. Sci.*, 1949, **18**, 404).

O. gamblei C.B. Clarke is a small tree found in the lower hills of Darjeeling at altitudes of 600-900 m. It yields edible fruits (Cowan & Cowan, 88).

Oleander — see *Nerium*

OLEANDRA Cav. (*Polypodiaceae*)

Beddome, Indian Ferns, 285, Fig. 146 & 147.

A genus of terrestrial or epiphytic ferns distributed in the tropics of both hemispheres. Three species are recorded in India.

O. neriformis Cav., a fern with wide-creeping, often sub-erect stems, short stipes and narrow-linear to oblong-acuminate fronds, is found in the Himalayas, from Nepal eastwards and in Khasi hills at an altitude of 600-1,500 m. A decoction of the stipes is considered to be an emmenagogue (Brown, 1941, I, 48).

O. wallichii Presl is an epiphytic fern with sub-elliptical-oblong fronds found in Kumaun, Mussoorie and Nepal at an altitude of 600-2,400 m. The rhizome is reported to possess rejuvenating properties and beneficial to the aged (Banerji, *J. Bombay nat. Hist. Soc.*, 1955-56, **53**, 154).

Oleaster — see *Elaeagnus*

Olibanum, Indian — see *Boswellia*

Oligoclase — see *Felspar*

Olive — see *Olea*

Olive, Russian — see *Elaeagnus*

ONCOBA Forsk. (*Flacourtiaceae*)

Chittenden, III, 1423 ; Flower, Pl. Sudan, I, 158.

A genus of shrubs or small trees distributed in Africa, Arabia, Malagasy (Madagascar) and Brazil. One species, *O. spinosa* Forsk., has been introduced into India and is grown in gardens.



FIG. 39—ONCOBA SPINOSA—FLOWERING BRANCH

O. spinosa is a thorny shrub or a small tree with white fragrant flowers and globose woody fruits. It is grown as a hedge. The fruits are sometimes eaten. They have a chrome yellow pulp, mealy in consistency and not a particularly pleasant flavour. The seeds yield 35% of a brownish yellow, drying oil (iod. val., 177), containing oleic, linoleic, and linolenic acids. The oil is suitable for use in paint and varnish industry, but has not attained commercial importance because of the difficulty in separating the seeds from the fruit pulp (Gopalaswamiengar, 235 ; Macmillan, 87, 262 ; Watt & Breyer-Brandwijk, 447 ; *Bull. imp. Inst., Lond.*, 1923, **21**, 585 ; Hilditch, 1956, 221).

The roots of the plant are reported to be used in dysentery and bladder disorders. The wood is hard and light brown ; it is suitable for inlay and cabinet work (Dalziel, 48).

ONCOSPERMA Blume (*Palmae*)

Fl. Br. Ind., VI, 414 ; Blatter, 428, Pl. 82.

A small genus of prickly palms distributed in Ceylon and Malaysia. Two Malaysian species have been introduced into India and are grown in gardens.

O. tigillarium (Jack) Ridley syn. *O. filamentosum* Blume is a tall tufted palm, 9-24 m. high, armed with black spines and graceful crown found in mangrove swamps and coastal areas in Malaysia. It has a hard wood durable under water and is used for house posts, piles and fishing stakes; it is also used for spear shafts. The split outer wood has great elasticity and has been employed for flooring, and as rafters for roofing and walls. Boards obtained from the outer wood take a fair polish and can be made into furniture and other articles (Burkill, II, 1581; Brown, 287).

From the leaves baskets are made. The bud is eaten raw or cooked though its removal causes death of the palm. The flowers are used for flavouring rice; fruits can be made into preserves and sometimes used as substitute for arecanuts (Burkill, II, 1581-82; Brown, 1941, I, 328).

O. horridum Scheff. is less tufted than the above species and its wood is used for similar purposes. A decoction of the root is said to be given in fevers. It is a source of palmite which is supposed to have an agreeable taste (Burkill, II, 1581; Uphof, 257).

Onion — see **Allium**

ONOSMA Linn. (*Boraginaceae*)

A genus of hairy herbs and undershrubs distributed in the Mediterranean region and central Asia. About two dozen species occur in India.

O. bracteatum Wall.

D.E.P., V, 486; Fl. Br. Ind., IV, 178; Kirt. & Basu, Pl. 656B.

HINDI & BENG.—*Gaozaban*.

A perennial hirsute or hispid herb sparsely distributed in north-western Himalayas from Kashmir to Kumaun at altitudes of 3,500-4,500 m. Stem simple, hairy, 30-50 cm. tall and 4-6 mm. diam., arising from a cluster of radical leaves; leaves with evident veins; radical leaves lanceolate, 12-30 cm. (including petiole) × 1.5-3.5 cm., with conspicuous, hairy pallid bases, caudine leaves lanceolate; flowers blue or purple, trumpet-shaped, in dense, silky, glomerate clusters; nutlets grey, coarsely rugose, tuberculate.

The dried leaves and flowers of *O. bracteatum*, according to earlier literature, constitute the drug, *Gaozaban*, imported from Iran, and used as tonic, alterative, demulcent, diuretic and refrigerant; it is reported to be useful as a spasmolytic. Recent studies have shown that the bazaar drug is derived not

from this plant, but from *Anchusa strigosa* Labill., which has not been recorded in India, but occurs in Iran. Further, the name *Gaozaban* is applied to six different plants, belonging to five genera. A drug sold in the bazaar under the name *Kashmiri Gaozaban* is derived from *Macrotomia benthamii* (q.v.) (Dandiya & Arora, J. Amer. pharm. Ass., sci. Edn, 1957, 46, 111; Qadry & Hamid, J. sci. industr. Res., 1962, 21C, 317; Handa et al., Indian J. Pharm., 1951, 13, 29).

O. hispidum Wall. ex D. Don syn. *O. cchioides* C.B. Clarke non Linn.

D.E.P., V, 487; Fl. Br. Ind., IV, 178.

HINDI & BENG. *Ratanjot*.

A perennial, erect or ascending herb occurring in western Himalayas from Kashmir to Kumaun at altitudes of 2,000-4,500 m. Root tapering, purplish red; stem simple or rarely branched, up to 75 cm. long and 3-6 mm. thick towards the base; leaves usually without visible veins, hispid with coarse hair having discoid bases; radical leaves narrowly oblanceolate and caudine leaves linear-oblong; flowers



FIG. 40—ONOSMA HISPIDUM—FLOWERING BRANCH

ONOSMA

odorous, whitish or pale yellow, in terminal cymes; nutlets 6 mm. long, smooth or obscurely roughened, somewhat lustrous.

This species is widely distributed in western Himalayas and has been erroneously identified as *O. echiooides* Linn., an European species, with which it is not related. A variety of this species, var. *kashmirenum* Johnston, is found in Kashmir (Johnston, *J. Arnold Arbor.*, 1951, **32**, 201).

O. hispidum has been reported to be the source of Ratanjot, a red dye yielding root, commonly used for colouring foodstuffs, oils and medicinal preparations. The commercial product, however, is imported into India from Afghanistan (amount imported, c. 6,000 kg.). A recent survey of literature and bazaar samples has indicated that the name Ratanjot is used in a generic sense to cover a range of red dye yielding materials, rather than to the root of a single species. As many as 15 plant species belonging to four different families are found to be associated with Ratanjot; five of them do not yield any red colouring matter. Further examination has shown that the source of commercial Ratanjot is *Arnebia nobilis* Rech. f. found in Afghanistan and not *O. hispidum* (Bole, *J. sci. industr. Res.*, 1961, **20C**, 183; 1962, **21C**, 354).

Commercial samples of Ratanjot yield a red colouring matter, sparingly soluble in water and soluble in alcohol, and in fats and oils. In general properties and colour reactions, it resembles Alkanet, from *Alkanna tinctoria* Tausch. (Perkin & Everest, 73).

Bruised roots of Ratanjot are applied externally to cutaneous eruptions; the flowers of the plant are used as stimulant and cardiac tonic. The root was formerly employed for dyeing wool. The use of Ratanjot as a visible colouring agent for Vanaspati (hydrogenated vegetable oils) has been suggested. Feeding trials on rats have shown that while in low concentrations, the colouring matter is non-toxic or only slightly toxic, in high concentrations and continued feeding, it causes destruction of liver cells. Also, the colour imparted to Vanaspati is completely removed by simple chemical treatment with alkali solution, and to a substantial extent by exposure to direct sunlight or heating. The dye does not appear to be suitable for colouring Vanaspati (Munro & Lall, *Indian J. vet. Sci.*, 1949, **19**, 11; Mukerji *et al.*, *Ann. Biochem.*, 1960, **20**, 105; Hatiangdi & Patel, *J. sci. industr. Res.*, 1961, **20C**, 30).

The roots of *O. emodi* Wall.=*Maharanga emodi*

(Wall.) DC., a herb frequently met with in the Himalayas from Garhwal to Bhutan at altitudes of 3,500-4,000 m. and in the Naga hills of Assam, afford a dye which has been used for colouring wool and silk.

The roots of *O. hookeri* C.B. Clarke, a herb found in Sikkim and Bhutan at altitudes of 4,000-4,500 m., is said to yield the best Lepcha red dye. In Iran, they are employed for colouring medicinal preparations. The powdered root is given to horses for coughs and as a condition powder. In Baluchistan, powdered leaves are used as purgative (Parsa, *Qualit. Plant. Mat. Veg.*, 1960, **7**, 85).

ONYCHIUM Kaulf. (*Polypodiaceae*)

Beddome, *Indian Ferns*, 95; Chittenden, III, 1430.

A small genus of graceful ferns distributed in Asia, Africa and tropical America. Seven species have been recorded in India.

O. japonicum (Thunb.) Kunze is a small handsome fern with creeping rhizome and pinnatifid fronds found in Kumaun, Mussoorie and Garhwal and in Khasi, Aka and Lushai hills at altitudes of 900-2,400 m. The fern is well suited for indoor decoration. A glycoside ($C_{27}H_{30}O_{14}$) which yields kaempferol and rhamnose on hydrolysis has been isolated from the leaves and rhizomes (Gopalaswamiengar, 385; *Chem. Abstr.*, 1951, **45**, 5686).

O. siliculosum (Desv.) C. Chr. (LUSHAI—Kangrem, *samairia*) is an elegant and decorative fern with pinnatifid fronds found in Mussoorie and Aka and Lushai hills, up to an altitude of 1,500 m. It is sometimes cultivated for its light, finely cut fronds of pleasing colour. The fern is propagated by means of spores. A decoction of the fronds is used for dysentery [Raizada, *Indian For.*, 1959, **85**, 689; Biswas, *Indian For. Rec., N.S., Bot.*, 1941, **3(1)**, 60; Fischer, *Rec. bot. Surv. India*, 1938, **12(2)**, 158; Brown, 1941, I, 48].

OPERCULINA Silva Manso (*Convolvulaceae*)

A small genus of herbaceous twiners distributed in the tropics of both hemispheres. One species occurs in India.

O. turpethum (Linn.) Silva Manso syn. *Ipomoea turpethum* R. Br.

D.E.P., IV, 493; C.P., 822; Fl. Br. Ind., IV, 212; Fl. Malesiana, Ser. I, **4(4)**, 456, Fig. 32a-b.

SANS.—*Trivrit*; HINDI—*Nisoth, nisotar, pitohri*; BENG.—*Dudh kalmi, tohri*; MAR.—*Nishottar, phut-*

kari; GUJ.—*Nashotar, nahoṭara*; TEL.—*Tellategada*; TAM.—*Shivadai, kumbam*; KAN.—*Bili tigade, bangada balli*; MAL.—*Chivaka, trikolpakonna, rochani, tribhandi*; ORIYA—*Dudholomo*.

A large perennial twiner with milky juice and fleshy branched roots found throughout India up to an altitude of 900 m.; it is occasionally grown in gardens for ornament. Leaves very variable in shape; flowers tubular-campanulate, white, in few flowered cymes; capsules globose with 4 or less, dull black, glabrous seeds.

O. turpethum is the source of the drug known as Turpeth or Indian Jalap and used as purgative. The drug occurs in two forms, white (*safed nisoth*) and black (*krishna nisoth*). It consists of cylindrical pieces of root and stem, 1.5–15 cm. long \times 1–5 cm. diam., often with central woody portion removed by splitting the bark on one side; external surface longitudinally furrowed giving the drug a rope-like appearance; fracture short in bark and fibrous in wood; odour distinct but unpleasant or musty; taste somewhat nauseating or bland at first, then slightly acrid. It is almost as effective as true jalap (*Exogonium purga*) and superior to rhubarb (*Rheum emodi* Wall. ex Meissn.), and useful in all affections where jalap or

rhubarb is indicated. The drug is administered in the form of powder; it may also be given in combination with cream of tartar in equal proportion. White turpeth is preferred to black turpeth as cathartic; the latter produces drastic purgation and causes vomiting, fainting and giddiness (I.P.C., 243–44; Datta & Mukerji, *Bull. Pharmacogn. Lab.*, No. 1, 1950, 98; Shah *et al.*, *Indian J. Pharm.*, 1961, 23, 192; Prasad *et al.*, *J. sci. industr. Res.*, 1961, 20C, 92).

Recent investigations have shown that white turpeth is sometimes derived not from *O. turpethum* but from *Marsdenia tenacissima* (Shah *et al.*, *Indian J. Pharm.*, 1961, 23, 192; 1960, 22, 284; Bhattacharya, *ibid.*, 1961, 23, 186; Wahi & Bhattacharya, *ibid.*, 1960, 22, 283; Prasad *et al.*, loc. cit.).

The active principle is a glycosidic resin (m.p., 183°; acid val., 20.5–24.5; sap. val., 160.5–164) present in the drug up to 10%. It is similar to jalap resin and is concentrated mostly in the root bark. The resin is brownish yellow and odourless with a bitter pungent taste. It is soluble in alcohol and partly soluble in ether. It contains an ether insoluble glycoside, turpethin, which constitutes about half of the resin, and two ether soluble glycosides, namely α -turpethin (8%) and β -turpethin (0.6%). Besides the resin, the drug contains a small amount of volatile oil and a yellow colouring matter (Datta & Mukerji, loc. cit.; Tschirch & Stock, II, 1618, 1633; Hoppe, 478).

Alcoholic extracts of fresh roots of *O. turpethum* show antibacterial activity against *Micrococcus pyogenes* var. *aureus* and *Escherichia coli*. Young leaves and tender stems are reported to be used as vegetable in Philippines. Stems are used for tying purposes [Kurup, *J. sci. industr. Res.*, 1956, 15C, 153; Intengan *et al.*, *Philipp. J. Sci.*, 1955, 84, 343; Fl. Malesiana, Ser. I, 4(4), 456].

OPHIOGLOSSUM Linn. (*Ophioglossaceae*)

A genus of ferns distributed throughout the world. Seven species occur in India.

O. vulgatum Linn.

Beddome, *Indian Ferns*, 464; Chakravarty, *Bull. bot. Soc. Beng.*, 1951, 5, 3, Fig. 1.

A small herbaceous fern found in the Himalayas, Bihar, Assam, Anaimalai and Shevaroy hills (S. India), up to an altitude of 2,700 m., and in Poona (Maharashtra). Rootstock small, spindle-shaped or ovate, with numerous roots; fronds 10–30 cm. long; sterile segment entire, 2–6 cm. \times 1–2.5 cm., upright,



FIG. 41—OPERCULINA TURPETHUM—FLOWERING BRANCH

OPHIOGLOSSUM

ovate or ovate-lanceolate or rarely cordulate, fertile segment including the stalk up to 24 cm. long, overtopping the sterile division.

The fern possesses antiseptic, detergent, styptic and vulnerary properties. The mucilaginous and astringent decoction of the fern is used in angina in Réunion. A warm decoction of the rhizome is used by the Sutos of southern Africa as a lotion for boils (Wren, 6; Kirt. & Basu, IV, 2751; Watt & Breyer-Brandwijk, 1087).

O. pendulum Linn., an epiphytic fern, is reported to occur in Assam. The long, pendulous ribbon-like fronds are shredded into coconut oil which is applied as an ointment in the scalp to improve the hair (Chakravarty, *Bull. bot. Soc. Beng.*, 1951, 5, 7; Burkill, II, 1583).

O. reticulatum Linn. (BENG.—*Ektir*; ASSAM—*Jibha*) is an upright terrestrial fern found in Mussoorie, Bihar, Bengal, Assam and S. India up to an altitude of 1,800 m. In Indonesia, the fern is eaten as salad and as a vegetable, alone or mixed with other vegetables (Burkill, II, 1583).

OPHIOPOGON Ker-Gawl. (*Liliaceae*)

Fl. Br. Ind., VI, 267; Bailey, 1947, II, 2355.

A small genus of herbs distributed in Central and East Asia. Twelve species are found in India, including one exotic species grown in gardens.



FIG. 42—OPHIOPOGON INTERMEDIUS

O. intermedius D. Don (BENG.—*Piyajimurba*) is a low perennial herbaceous weed found in temperate Himalayas, from Kashmir eastwards to Sikkim, Khasi hills, Manipur and Orissa and also in the hills of S. India at altitudes of 900–3,100 m. The tubers of the plant are said to be used in dropsy (Biswas, 91).

O. japonicum Ker-Gawl., a stoloniferous perennial herb, native of Japan and Korea, with tuberous roots and violet-purple or lilac flowers, is grown in Indian gardens for edging. The mucilaginous tubers of the plant are edible and used as a substitute for ginseng (*Panax schinseng* Nees). The rhizomes are medicinally important in Indo-China and used as a febrifuge and galactagogue; they are employed for reducing the inflammation of the lungs and for liver, kidney and intestinal complaints (Firminger, 325; Willis, 465; Hoppe, 619; Crevost & Petelot, *Bull. econ. Indoch.*, 1935, 38, 118).

OPHIORRHIZA Linn. (*Rubiaceae*)

A genus of herbs, rarely undershrubs, distributed in tropical Asia, Australia and Polynesia. Nearly 45 species are reported to occur in India.

O. mungos Linn. MONGOOSE PLANT

D.E.P., V, 488; Fl. Br. Ind., III, 77; Kirt. & Basu, Pl. 493.

HINDI—*Sarabati*; BENG.—*Gandhanakuli*; MAR.—*Mungusavela, nagvelli*; GUJ.—*Mungusvel*; TEL.—*Chettu*; TAM.—*Keerippundu*; KAN.—*Mungisigida, patalagaruda, sarpari*; MAL.—*Avilpori*.

A suffrutescent herb, 45–60 cm. high, found in Khasi hills, western ghats from Wynnaud to the Anaimalais, hills of Travancore and Tirunelveli at low elevations and in Andaman and Nicobar Islands. Leaves elliptic-lanceolate, acuminate, long-attenuate at base; flowers white, in sub-umbellate cymes; fruits compressed, coriaceous; seeds numerous, angular, pale brown.

The roots of the plant are intensely bitter and may be used as a tonic. Because of their reputed property against snake bite, they have been studied with respect to their antidotal properties and have been shown to be useless. They contain starch, a light brown resin and small amounts of a bitter amorphous alkaloid. β -Sitosterol, 5α -ergost-7-en-3 β -ol and 5α -ergost-8-(14)-en-3 β -ol (as an ester) have been identified in root extracts. Leaves and stems contain traces of hydrocyanic acid (Kirt. & Basu, II, 1268; Dymock, Warden & Hooper, II, 201; Agarwal & Dhar, *J. sci. industr. Res.*, 1959, 18B, 114; Quisumbing, 1047).

The roots are said to be useful in the treatment of cancer. A decoction of roots, leaves and bark is given as a stomachic. Leaves are used for dressing ulcers. A paste made from the scrappings of stem is used in making scabbards and guitars (Agarwal & Dhar, loc. cit.; Nadkarni, I, 872; Quisumbing, 922; Fox, Philipp. J. Sci., 1952, 81, 362).

OPIEUROS Gaertn. f. (*Gramineae*)

D.E.P., III, 424; Fl. Br. Ind., VII, 160.

A genus of grasses distributed chiefly in the tropics of the Old World. Four species are found in India.

O. exaltatus (Linn.) Kuntze syn. *O. corynibus* Gaertn. f.; Hook. f. (Fl. Br. Ind.) in part (TEL.—*Pedda panuku*; TAM.—*Kinangu pillu*, *sothu alagu pillu*; NORTH, WESTERN & CENTRAL INDIA—*Hutia*, *gunit*, *sontha*) is a much-branched perennial, 1-2 m. in height, with linear leaves found in western, central and north-eastern parts of India and in the Deccan Peninsula. This grass is much used for thatching. It is also eaten by cattle when young. The average composition of Indonesian samples gave (dry basis): protein, 6.89; fat, 1.96; carbohydrates, 42.45; fibre, 34.30; and ash, 14.40%. *O. megaphyllus* Stapf ex Haines syn. *O. corymbosus* Hook. f. (Fl. Br. Ind.) in part, non Gaertn. f. is a closely related but more robust species found in Assam and Bihar; it does not seem to be discriminated from *O. exaltatus* for economic uses (Bor, 1960, 199; Tiwari, Indian For., 1955, 81, 107; Walandouw, J. sci. Res. Indonesia, 1952, 1, 201).

Opium — see **Papaver**

OPLISMENUS Beauv. (*Gramineae*)

A small genus of creeping leafy grasses distributed in tropical and sub-tropical regions. Three or four species have been recorded from India.

O. burmannii (Retz.) Beauv.

D.E.P., III, 424; V, 489; Fl. Br. Ind., VII, 65.

HINDI—*Nini*; TAM.—*Mungil pillu*; ORIYA—*Kau-guria*.

UTTAR PRADESH—*Bans-pati*, *bawanta*; BOMBAY—*Kudak*, *yerwa*.

A delicate leafy grass, with diffusely branched culms, up to 50 cm. high, found growing often gregariously in shady places nearly throughout the plains of India and at lower elevations on the hills. It is much relished by cattle, particularly when young and green; it also yields a good hay. Analysis of the grass gave the following values (dry wt. basis):



FIG. 43—OPLISMENUS BURMANNII

crude protein, 1.31; fibre, 20.70; total ash, 14.91; ash sol. in HCl, 13.56; calcium, 0.6; phosphorus, 0.17; magnesium, 0.21; and potassium, 1.72%. The grass is said to be used in Java in the form of a decoction during pregnancy [Bor, Indian For. Rec., N.S., Bot., 1941, 2(1), 158; Bor, 1960, 317; Sen, Bull. Indian Coun. agric. Res., No. 25, 1952, 20; Burkill, II, 1585].

O. compositus (Linn.) Beauv. (TEL.—*Kodijuttu gaddi*; U.P.—*Basahre*) is a tall perennial grass distributed throughout India, ascending up to 2,400 m. It is variable and numerous forms are known. It is said to be eaten or grazed by cattle in some areas, while in others it is stated to be disliked even by horses (Bor, loc. cit.; Rhind, 54; Haines, V, 999).

O. undulatifolius (Ard.) Beauv., found in the Himalayas at elevations of 2,700 m. from Kashmir to Sikkim and in Assam, is said to be eaten by goats and sheep, but not by cattle (Bor, loc. cit.).

OPOPANAX Koch (*Umbelliferae*)

D.E.P., V, 489; Chittenden, III, 1432.

A small genus of herbs distributed in southern Europe and the Orient. One species, *O. chironium*,

OPOPANAX

yields a gum resin called Opopanax which was imported into India and used in medicine. The plant, however, does not occur in India.

O. chironium Koch, a hardy perennial herb, 1.8 m. high, with 2-pinnate leaves and yellowish flowers, is a native of southern Europe, Asia Minor and Iran.

The root of the plant on incision yields a milky juice which hardens and becomes a gum resin known as Opopanax (HINDI & BOMBAY—*Juvashur*; BENG.—*Jawe-shi*). It occurs as hard nodular lumps of an orange brown colour, and possesses a penetrating offensive odour and a bitter and acrid taste. It has a specific gravity of 1.622 ; it contains 3% essential oil. Opopanax has been used in earlier times in indigenous medicine as stimulant, antispasmodic and anti-septic but its use at present is doubtful (Howes, *Econ. Bot.*, 1950, 4, 307 : Nadkarni, I, 872 : U.S.D., 1947, 1536 ; *Chem. Abstr.*, 1937, 31, 1955).

Considerable doubt exists with regard to the exact source of opopanax of commerce. The plant species referred to as sources are *O. chironium*, *Commiphora erythraea* (Ehrh.) Engl. var. *glabrescens* Engl. and *C. kataf* Engl. The commercial opopanax of today, also called Sweet Myrrh or Bissabol Myrrh, is derived from *Commiphora erythraea* var. *glabrescens* of Somaliland. Opopanax derived from *O. chironium* has become a rarity and its occurrence in Indian bazaars appears to be doubtful, though one authority has stated that it is available in bazaars of Bengal [Krishna & Badhwar, *J. sci. industr. Res.*, 1952, II A(12), suppl., 246 ; 1948, 7(8), suppl., 126 ; Hill, 174 : Guenther, IV, 349].

OPUNTIA Mill. (*Cactaceae*)

A large genus of succulent shrubs, native of the New World, now widely grown in the warmer parts of the world, on account of their unique appearance and attractive flowers. Seven to eight species have been introduced into India, but only 2 or 3 have been naturalized : they are commonly known as Prickly Pears, because of their edible fruits.

The prickly pears are said to have been accidentally introduced into India and other eastern countries by early European travellers, who used to carry these plants for use as vegetable to prevent scurvy during their long voyages. In India, as well as in other countries, they spread with rapidity and soon became noxious weeds, monopolising large areas of forest and cultivated lands. Efforts were, therefore, made to eradicate them by mechanical, chemical and biological methods or utilize them for some

economic purposes. They were all found difficult and unprofitable. But by an accident, biological control of prickly pears by the cochineal insect proved successful. This insect was introduced in the latter part of the 18th century in various countries, with a view to explore the possibility of cultivating it on prickly pears for purposes of the valuable dye obtained from it. In India, the wild form of cochineal insect which was introduced for this purpose proved to be that of *Dactylopius indicus* Green and not the genuine dye-yielding cochineal insect *Dactylopius cacti* (Linn.). The dye obtained from *Dactylopius indicus* proved very inferior from the commercial point of view and consequently the dye collection was given up. However, the insect, which thrived well on the prickly pears became so destructive as to kill off most of the species which had become a pest by then throughout the country. Their destruction, however, was not uniform. While they were very successful in eradicating some types of prickly pears in the northern parts of the country, they failed to completely curb some types of cacti in the southern parts, in spite of their repeated introduction. This apparent inconsistency in the behaviour of cochineal insect became clear much later, when the taxonomy of the prickly pears in India was fully investigated and the food habits of the different species of cochineal insect became known. It was found that cacti in India did not all belong to one species, *O. dillenii* as was assumed, but to three or four species distributed over different regions in India. *O. dillenii* Haw. was found mainly in the southern parts of the country, while *O. vulgaris* Mill. (syn. *O. monocantha* Haw.) was distributed mainly in the northern parts ; *O. elatior* Mill. was found mainly in western India. The wild cochineal insect *D. indicus* was found to feed only on *O. vulgaris* and not to thrive on the other two species, thus explaining the failure of this insect to control *O. dillenii* and *O. elatior* in southern and western India. Another wild cochineal insect *Dactylopius tomentosus* Linn., introduced later into this country from Ceylon in 1926, proved effective in controlling the latter two species [Burkill, II, 1586 ; Burkill, *Rec. bot. Surv. India*, 1911, 4(6), 281 ; Rama-krishna Ayyar, *Agric. Live-Stk India*, 1931, 1, 229 ; Deshpande, *ibid.*, 1935, 5, 36 : Wlth India—Raw Materials, II, 258].

O. dillenii Haw. PRICKLY PEAR, SLIPPER THORN

D.E.P., V, 490 (in part) ; C.P., 822 ; Fl. Br. Ind., II, 657 (in part) ; Parker, 259.

HINDI—*Hathhathoria, nagphana*; BENG.—*Nagphana*; MAR.—*Chopal*; GUJ.—*Chorhathalo*; TEL.—*Nagajemudu*; TAMIL.—*Nagathali, sappathikalli*; KAN.—*Papaskalli*; MAL.—*Palakkallu*; ORIYA—*Nagophenia*.

PUNJAB—*Chhittarthohar*.

An erect shrub, about 2.0 m. high, with broadly ovate, dull bluish green joints, bearing 4-6, pale yellow or light horn-coloured spines on each areole : spines usually somewhat curved, the largest very stout, 2.5-3.8 cm. long; flowers yellow, tinged with orange at the base; fruits pyriform, truncate, depressed at the apex, deep reddish purple when ripe.

This species is found nearly throughout India, but more commonly in S. India. It has been much used as a hedge because of its ability to thrive in the poorest and driest of soils and the ease with which it could be propagated; further its spiny nature affords a good degree of protection.

O. dillenii is believed to have reached S. India by about the middle of the 18th century and from there spread to other parts, because of its wide use in making hedges round fields; for the latter purpose

it has been preferred to *O. vulgaris*, as it is more spiny. While *O. vulgaris* was brought under control earlier in S. India by the introduction of the wild cochineal, *Dactylopius indicus*, *O. dillenii* continued to thrive for some more time, until another wild cochineal, *D. tomentosus*, was introduced, to which it succumbed [Burkill, *Rec. bot. Surv. India*, 1911, 4(6), 318; Deshpande, *Agric. Live-Stk India*, 1935, 5, 36].

Before the prickly pear pest was brought under control, various attempts were made to make use of the plant as fodder for livestock, as a source of alcohol and as a soil fertilizer. Trials as a cattle fodder yielded fairly satisfactory results. Mixed with 6% of its weight of cottonseed, it was found to have no ill effects in over six months of feeding. For being used as feed, however, the thorns had to be burnt off with a burner. Analysis of the green plant gave the following values: moisture, 85.0; nitrogen, 0.14; carbohydrates, 3.48; crude fibre, 2.15; ash, 1.82; phosphate (P_2O_5), 0.015; and potash (K_2O), 0.22% (Troup, II, 613; Horn & Muktekar, *Agric. J. India*, 1914, 9, 190; ibid., 1921, 16, 208; Fowler & Gopalakrishnamurti, *J. Indian Inst. Sci.*, 1923, 6, 173).

The fruits are edible and contain nearly 8% of fermentable sugar, mainly as monosaccharide. They could be utilized as a profitable source of industrial alcohol, provided an yield under cultivation of 25.100 kg. or more of fruits per hectare, yielding about 500 litres of spirit, can be obtained. Analysis of the fruits gave the following values: moisture, 5.67; albuminoids, 6.25; fat, 3.63; carbohydrates, 41.89; fibre, 32.0; and ash, 10.56% (Kew Bull., 1925, 194; Fowler & Gopalakrishnamurti, loc. cit.).

The plant yields a coarse fibre which has been tried as a source of paper pulp. The pulp produced is short-fibred, the yield is low and the amount of reagents required for pulping relatively great (*Madras agric. J.*, 1918, 6, 251; *Agric. J. India*, 1921, 16, 465).

The plant contains a mucilage which can be extracted by boiling the material and straining the liquid. The mucilage contains galactose, glucose and arabinose. It may be used as a drier in white or colour wash, which becomes fast and does not rub off easily (*Indian For.*, 1916, 42, 517; Wehmer, II, 811).

The flowers contain the glycosides of isorhamnetin and quercetin in the proportion of 3:1, with small amounts of the free flavonols (Nair & Sankara Subramanian, *J. sci. industr. Res.*, 1961, 20B, 507).

It is reported that a good farmyard manure can be made by composting prickly pear plants. Ether extract of the stem is reported to have some

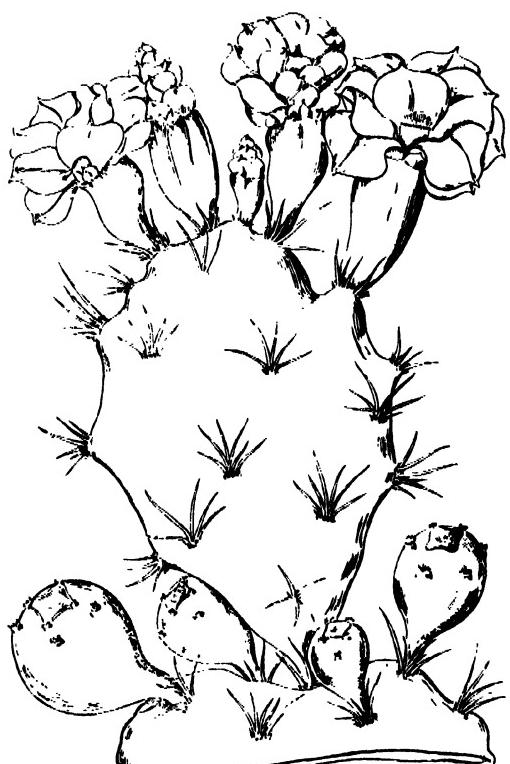


FIG. 44—OPUNTIA DILLENII—IN FLOWER AND FRUIT

OPUNTIA

antibiotic activity (*Indian For.*, 1916, **42**, 517; Joshi & Magar, *J. sci. industr. Res.*, 1952, **11B**, 261).

The baked fruit is said to be given in whooping cough and a syrup of the fruit is said to increase the secretion of bile and control spasmodic cough and expectoration. The joints mashed up are used as a poultice to allay inflammation and the hot joint applied to boils to hasten suppuration and for poulticing guinea worm abscesses. The joint made into pulp is also said to be applied to eyes in cases of ophthalmia (Kirt. & Basu, II, 1177).

O. elatior Mill. syn. *O. nigricans* Haw.

D.E.P., V, 490 (in part); Burkill, *Rec. bot. Surv. India*, 1911, **4(6)**, 313; Santapau, *ibid.*, 1953, **16(1)**, 123.

A large succulent shrub with ovate-oblong limbs, having 2-5 spines on each areole; flowers at first yellow, turning pink or bright red later; fruits bright red or reddish purple when mature.

This is the common prickly pear of western India, but recorded also in S. E. Punjab, Uttar Pradesh, Madhya Pradesh, Orissa and N. Circars. It is said to have been introduced about A.D. 1800 and has often been mis-identified as *O. dillenii*, from which it is distinguished by its yellow flowers, which soon change to rose-pink and the spines which are all straight, slender, tawny or brownish in colour.

The plant has been used in the same way as *O. dillenii*. The fruits are eaten and the plants are fed to cattle as famine ration after burning off the spines. Analysis of the plant gave the following values (dry basis): albuminoids, 6.34; ether extr., 3.31; soluble carbohydrates, 58.12; and fibre, 13.48%. The joints have been sometimes used as green manure in western India. The air-dried joints contain: N, 0.15; potash (K_2O), 0.18; and phosphoric acid (P_2O_5), 0.10% (Knight, *Bull. Dep. Agric. Bombay*, No. 97, 1920, 11; Sahasrabuddhe, *ibid.*, No. 174, 1933, 15).

Its eradication has been effected mainly by the introduction of *Dactylopius tomentosus*, the wild cochineal responsible for destruction of *O. dillenii* in Madras State (Deshpande, *Agric. Live-Stk India*, 1935, **5**, 36).

***O. ficus-indica** (Linn.) Mill. INDIAN FIG

Bailey, 1947, II, 2361, Fig. 2598.

A large bushy or tree-like cactus with oblong or

elliptic joints, 30-50 cm. long, usually spineless; flowers yellow; fruits purple or red, 5-10 cm. long. This spineless cactus is said to have been introduced early in this country and has shown no tendency to run wild as the other species. It is mostly cultivated in gardens, except for one or two attempts to grow it on a plantation scale in western India. It is said to be widely grown in Mexico and Mediterranean countries for its edible fruits, which in some races are said to be seedless [Burkill, *Rec. bot. Surv. India*, 1911, **4(6)**, 289].

This spineless cactus, unlike the other prickly pears, is not affected by the wild cochineal insect (*Dactylopius* spp.) and has been, therefore, suggested as suitable for cultivation as fodder reserve in areas threatened by famines. It is easily cultivated and can be raised from single joints planted during dry weather in rows 3 m. apart, with slight watering and occasional harrowing. Under favourable conditions it yields about 125,500 kg. of fodder per hectare in a year. It can be fed to cattle, after passing through a chaff cutter, at the rate of 45.4 kg. of cactus mixed with 2.7 kg. of cottonseed or any other dry feed. As the plants are spineless, they are readily browsed by stray cattle, goats and wild pigs and the plantation needs protection by an efficient thorny hedge. The plants are also subject to attack by the fungal species of *Diplodia* and *Pythium* (Burns, *Indian Fmg.*, 1940, **1**, 160; *Agric. J. India*, 1923, **18**, 417).

Analysis of green forage (moisture, 93.8%) from South Africa gave the following values (dry basis): crude protein, 6.8; ether extr., 1.9; N-free extr., 62.6; crude fibre, 10.5; ash, 18.2; calcium, 3.34; potassium, 4.55; and phosphorus, 0.16% (*Jt Publ. imp. agric. Bur.*, No. 10, 1947, 208).

Ripe fruits are delicious and are eaten. The colouring matter of the fruits is said to be excreted in the urine. Fruits are also dried and used for making sweetmeats and fermented liquors. They have been tried as a source of industrial alcohol; fermentation of glucose is, however, slow. Analysis of the flesh (63%) of ripe fruit gave the following values: moisture, 90.21; protein, 1.54; fat, trace; total sugars, 5.60; ash, 0.33; calcium, 0.018; and phosphorus, 0.14%. Fruit juice contains ascorbic acid (42 mg./100 g.), carotene (9 µg./100 g.), organic acids (0.08%, as citric acid), pectic substances and gum (Burkill, II, 1586; Winton & Winton, II, 792, 795, 798; *Biol. Abstr.*, 1948, **22**, 684; *Chem. Abstr.*, 1957, **51**, 8274).

The seeds are nutritious and may be used as an animal feed after grinding; they contain: moisture,

* According to Burkill [*Rec. bot. Surv. India*, 1911, **4(6)**, 288], who has been followed by all Indian authors, this plant should be called *O. decumiana* Haw.: 'it certainly is not Miller's plant, nor is it Linnaeus'.



Photo : Naresh Bedi

OPUNTIA ELATIOR — IN FLOWER

13.56 ; protein, 12.06 ; fat, 5.36 ; N-free extr., 37.11 ; fibre, 11.07 ; and ash, 20.84%. The fatty oil extracted from the seeds (iod. val., 125 ; sap. val., 194 ; acet. val., 24.5) is semi-drying in character and yields 13.3% saturated acids (*Biol. Abstr.*, 1948, 22, 684 ; Eckey, 702).

A mucilage or gum with excellent adhesive properties can be extracted from joints and other parts of the plant by pressing or boiling or soaking the material in water and straining. It resembles gum tragacanth in being almost insoluble in water but swelling to a jelly-like mass. The gum obtained from the fruit contains bassorin with an acid character and on hydrolysis yields pentoses ; that from the flowers contains mannose and galactose (Howes, 1949, 64 ; *Chem. Abstr.*, 1949, 43, 3662 ; 1957, 51, 8274 ; 1937, 31, 5105).

A decoction of the flowers acts as a diuretic, probably because of high potassium content. The juice of the joint has emollient properties (*Chem. Abstr.*, 1940, 34, 1442 ; 1957, 51, 8274).

The plant juice has been successfully used as a culture medium for certain industrially important micro-organisms, such as *Penicillium notatum*, *Aspergillus* spp., *Lactobacillus* sp. and *Mucor* sp. (*Hort. Abstr.*, 1952, 22, 418).

O. vulgaris Mill. syn. *O. monocantha* Haw.

Burkill, *Rec. bot. Surv. India*, 1911, 4(6), 312 ; Parker, 258.

A large succulent shrub, 1.8-2.4 m. high, with bright green joints and arcoles, bearing 1-3 spines ; spines straight, usually deciduous, with the exception of the largest which is up to 5.0 cm. long ; flowers golden yellow ; fruits reddish purple.



FIG. 43—OPUNTIA VULGARIS

This species has been recorded from all parts of India, but is reported to have been more commonly met with in the north than in the south. It is believed to have been the earliest species brought to India and already well established throughout the country by the end of the 18th century, when the authorities of the East India Company proposed to utilize prickly pears for the cultivation of the cochineal insect. This species, however, was nearly wiped out by the wild cochineal insect *Dactylopius indicus*, to which it became particularly susceptible. Its occurrence in India now is rare [Burkill, *Rec. bot. Surv. India*, 1911, 4(6), 292, 297, 308, 318 ; Ramakrishna Ayyar, *Agric. Live-Stk India*, 1931, 1, 229 ; Deshpande, *ibid.*, 1935, 5, 36].

The fruit is edible ; its flesh contains sugar (5-6%), ascorbic acid (6 mg./100 g.), a red colouring matter and calcium malate. Seeds yield 8-9% of a fatty oil (Wehmer, II, 810 ; Thorpe, X, 214).

Fresh stalks of *O. vulgaris* on extraction with hot water and precipitation with alcohol yield 0.7% of calcium magnesium pectate, which possesses anti-haemorrhagic action ; also the pectate when added to penicillin prolongs its action *in vivo* ; it appears to be non-toxic. A flavonoside (m.p. 182-84°), which resembles rutoside in its action of inhibiting capillary fragility, can be obtained from dried flowers in a yield of 2% ; on hydrolysis, it produces trihydroxy-methoxy-flavonol and glucose. The plant is reported to contain an alkaloid ; it also yields a mucilage which gives arabinose and galactose (*Chem. Abstr.*, 1949, 43, 6368 ; 1951, 45, 9807 ; Manske & Holmes, IV, 24 ; Smith & Montgomery, 22).

O. cochinellifera Mill.=*Nopalea cochenillifera* Salm-Dyck (COCHINEAL CACTUS ; TAM.—*Puchikalli*), a shrubby, spineless cactus with thick oblong segments, bright red flowers and reddish fruits, is often referred to a separate genus *Nopalea* Salm-Dyck, because of the exerted stamens. It is probably indigenous to Mexico, but cultivated widely in the tropics. It was particularly valued as a host for the cochineal insect (*Dactylopius cacti* Linn.), yielding the scarlet dye. It was introduced into India towards the end of the 18th century, but failed to get a firm hold in the country. It is frequently met with in gardens (Wtth India—Raw Materials, II, 258).

The fruits of the plant are edible ; they are said to be emollient and bechic. The mucilaginous joints are useful as poultices in cases of articular rheumatism, inflammation, scalds, burns, skin diseases, earache and toothache [Burkill, *Rec. bot. Surv. India*, 1911,

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4(6), 311, 321; Parker, 258; Kirt. & Basu, II, 1174; Hocking, 151; Quisumbing, 636].

Orange — see Citrus

Orange Chromide — see Fish and Fisheries

(Wlth India, IV suppl.)

Orange Jessamine — see Murraya

Orange, Osage — see Maclura

Orchard Grass — see Dactylis

Orchil — see Lichens

ORCHIS Linn. (*Orchidaceae*)

D.E.P., V, 492; VI (2), 385; Fl. Br. Ind., VI, 126.

A genus of terrestrial orchids distributed chiefly in Europe, temperate Asia and N. Africa, with a few species occurring in North America and Canary Islands. About a dozen species occur in India of which one species *O. latifolia* Linn. is said to yield Salep of commerce.

The tuberous roots of some orchid genera, including *Orchis* yield the salep. Most of the salep used in India is imported from Iran and Afghanistan, some of which is probably of European origin.

Salep consists of washed, scalded and dried tubers which are yellowish white or greyish in colour and rounded, ovate or digitate in form (0.5–2 cm. x c. 4 cm.), having somewhat wrinkled appearance and hard corny consistency. They are to some extent translucent, odourless and nearly tasteless. They are used as farinaceous food, nervine tonic and aphrodisiac. They yield a lot of mucilage with water and form a jelly, supposed to be nutritious and useful in diarrhoea, dysentery and chronic fevers. A decoction of salep containing some sugar and flavoured with spices makes an agreeable drink for the sick. Salep is also used as a sizing material in silk industry (Kanny Lall Dey, 211–12; U.S.S.R.P., 306; Khan, *Pakist. J. For.*, 1958, 8, 347; Steinmetz, II, 395).

Salep powder is whitish or yellowish in colour and, as specified in Russian Pharmacopoeia, should yield not more than 1.4% moisture and 3% ash (U.S.S.R.P., 306–07).

The tubers of *O. latifolia*, a herb with purple flowers found in damp places in the Himalayas from Kashmir to Nepal at altitudes of 2,500–5,000 m., contain a bitter principle and a volatile oil. An infusion of the tubers is used to relieve hoarseness. The leaves contain a glucoside, loroglossin ($C_{11}H_{20}O_6$, m.p. 149–51°) (Wehner, I, 186; Hoppe, 621; Parsa,

Qualit. Plant. Mat. Veg., 1960, 7, 86; Heilbron & Bunbury, III, 188).

OREOCNIDE Miq. (*Urticaceae*)

A small genus of shrubs or trees distributed from India to Japan and New Guinea. Two species are found in India.

O. integrifolia Miq. syn. *Villebrunea integrifolia* Gaudich Risa

D.E.P., VI (4), 238; C.P., 164; Fl. Br. Ind., V, 589.

NEPAL—*Lipe*; LEPCHA—*Kuffyet-kee*; ASSAM—*Banrhea, risa, mesakhi, lukoi, chho-oi-paroli, tillejuat, dieng-jei-thang-sim, sejugbu*.

A large evergreen shrub or a small tree found in the eastern Himalayas, Assam, parts of Orissa and in the western ghats from Konkan southwards, ascending up to an altitude of 1,350 m. Bark greyish, thin, fibrous; leaves elliptic-oblong or slightly lanceolate; flowers in globose cymose clusters, greenish; fruit an achene, seated on fleshy bracteoles.

The bark yields a fibre, which because of its resemblance with rhea (*Boehmeria nivea*) is commonly called Ban (wild) Rhea. It has, however, merits and properties different from rhea or other so called wild rheas and, has been called Risa. The risa plant is found abundantly in eastern Himalayas and Assam, where the fibre is extracted locally at many places. It thrives in damp and shady places near streams, but does not grow well in exposed situations. Though not systematically cultivated, it is encouraged to grow or even planted along embankments, roadsides and on slopes in tea estates: it can also be grown as a catch crop in tea estates. Propagation may be done by seeds, root cuttings or slips.

For fibre purposes the plant is pollarded between November and January and the young shoots become available in the next rainy season from June onwards. Though various crude and cumbersome processes have been followed in the past to extract fibre from the stems, it is now obtained by water-retting; good quality of fibre can be obtained by employing modern methods of extraction and chemical separation. It contains little or no gum as in rhea and does not require degumming machinery or methods. The risa fibre is white or brown in colour and has a silky lustre (length, 25–30 mm.; diam., 0.013 mm.); it is reported to be superior to ordinary rhea in strength, texture and composition. It is used for making ropes, cordage, nets, fishing lines and sack cloth, and is suitable for canvas and textiles (Sircar, *Misc. Bull. Indian Coun.*

agric. Res., No. 66, 1948, 60; *Dastur, Useful Plants, 220*.

O. frutescens Miq. syn. *Villebrunea frutescens* Blume (KUMAUN—*Gartushiara, poidhaula*; NEPAL—*Kirma*; LEPCHA—*Takbriet-kung*) is a shrub or a small tree found throughout the outer Himalayas, hills of Assam, Bihar and the Nilgiris up to an altitude of 1,500 m. It yields a fibre similar to that of *O. integrifolia*, and considered suitable for fishing lines and nets.

Oreodoxa—see *Roystonea*

Oriental Sweet Gum—see *Liquidambar*

ORIGANUM Linn. (*Labiatae*)

A small genus of perennial herbs or undershrubs distributed in the Mediterranean region and extrazonal Asia. One species occurs in India.

O. vulgare Linn. COMMON OR WILD MARJORAM

D.E.P., V, 494; Fl. Br. Ind., IV, 648; Mukerjee, *Rec. bot. Surv. India*, 1940, 14(1), 94; Kirt. & Basu, Pl. 759A.

HINDI—*Sathra*; TEL.—*Mridu-maruvamu*; KAN.—*Maruga*.

PUNJAB—*Mirzanjosh*.

An aromatic, branched perennial herb, 30–90 cm. high, found in the temperate Himalayas from Kashmir to Sikkim, at altitudes of 1,500–3,600 m.

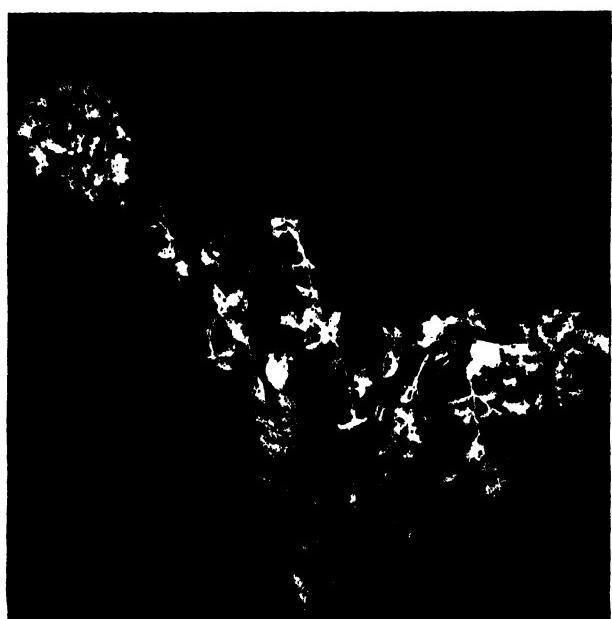


FIG. 46—*ORIGANUM VULGARE*—FLOWERING BRANCH

Leaves broadly ovate, entire or rarely toothed; flowers purple or pink, in corymbose cymes; nutlets smooth, brown.

O. vulgare is very common in Simla hills and in Kashmir valley. It is hardy and can be grown in all warm garden soils. It is propagated by seeds, cuttings, layers and root-division. It can be sown during October in the plains and during March and April in the hills [Handa *et al.*, *J. sci. industr. Res.*, 1957, 16A(5), suppl., 20; Chittenden, III, 1445; Heeger, 552; Firminger, 139; Gollan, 47].

The plant possesses an aromatic, thyme-like flavour. The leaves and tops cut prior to blooming are used to flavour foods in the same way as Sweet Marjoram (*Majorana hortensis*). The plant is used in Punjab as a pot-herb; it is eaten also as vegetable in Lahul. It was formerly employed to flavour ale and beer, before hops were introduced in the brewing industry (Muenscher & Rice, 91).

The herb contains a volatile oil (0.15–0.40%), tannin (c. 8%) and a bitter principle. The oil of European origin [sp. gr.¹⁵/₁₅, 0.868–0.910; Δ^{20} to 20° to possess an aromatic, spicy, somewhat basil-like odour and contains thymol (up to 7%), carvacrol, free alcohols (c. 13%), esters (as geranyl acetate, 2–3%) and a bicyclic sesquiterpene (12.5%). Steam-distillation of the whole plant from Kashmir gave a pale yellow oil (yield, 0.2%) with a pleasant smell and the following characteristics: sp. gr.²⁷/₁₅, 0.8812; n^{27} , 1.4795; $[\alpha]_D^{27}$, -1.5°; acid val., 2.5; ester val., 10.4 (after acetylation, 102.7); phenol content, nil; freely sol. in 90% alcohol. It contained *dl*-pinene, dipentene, linalool, bi- and tri-cyclic sesquiterpenes and palmitic acid. The oil called Oil of Origanum in trade is really Thyme oil (from *Thymus vulgaris* Linn.). Oil of *O. vulgare* is often confused with sweet marjoram oil (from *Majorana hortensis*) which is, however, dextrorotatory (up to +40°) (Hoppe, 624; Guenther, III, 542; Singh *et al.*, *J. sci. industr. Res.*, 1959, 18B, 128; Fuller, 766; Wtth India—Raw Materials, VI, 227).

The oil (Origanum Oil) possesses carminative, stomachic, diuretic, diaphoretic and emmenagogue properties; it is given as a stimulant and tonic in colic and diarrhoea; it is also applied in chronic rheumatism, toothache and earache. Due to the spasmolytic action of the oil, it is used in whooping cough and bronchitis. In homoeopathy, it is used for hysterical condition. It is used as an external application in healing lotions for wounds, usually in conjunction with other herbs. The oil has been

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employed in veterinary liniments. It is used in gargle and bath; it stimulates growth of hair. The oil is used in cosmetic and soap industry (Hoppe, 624; Kirt. & Basu, III, 1987; Martindale, I, 1381; Youngken, 719).

The herb is stated to be cultivated in Poland for its seeds from which a fatty oil is extracted in a yield of 29.2% (*Chem. Abstr.*, 1957, 51, 8455).

Origanum majorana — see **Majorana**

ORMOCARPUM Beauv. (*Leguminosae*; *Papilionaceae*)

Fl. Br. Ind., II, 152.

A genus of shrubs or small trees distributed in the tropical and sub-tropical regions of the world. One species occurs in India.

O. cochinchinense (Lour.) Merrill syn. *O. sennoides* DC.; *O. glabrum* Teijsm. & Binn.* (SANS.—*Kanana-shekvara, kananashigru*; TEL.—*Advimunaga, gunangi, nal kashina*; TAM.—*Kattumuringai*; KAN.—*Kadunugga*; MAL.—*Kattumuringa, punamurinna*) is a shrub with membranous leaflets, yellow flowers and moniliform pods found in Orissa, Deccan and South India. The roots are considered tonic and stimulant and are used in the treatment of lumbago; an application prepared by rubbing the root bark in oil is used in paralysis. The plant is considered to be a fish poison and probably contains rotenone or a related compound (Kirt. & Basu, I, 748; Rama Rao, 114; Webb, *Bull. Coun. sci. industr. Res. Aust.*, No. 232, 1948, 91).

In Java, the shrub is grown as a support for pepper and for shade in coffee and cacao plantations (Burkill, II, 1588).

ORMOSIA G. Jackson (*Leguminosae*; *Papilionaceae*)

D.E.P., V, 494; Fl. Br. Ind., II, 252.

A genus of evergreen trees or shrubs distributed throughout the tropics. Three species are found in India.

O. travancorica Bedd. (TAM. & MAL.—*Malei manchadi*) is a tall handsome tree, c. 24 m. in height, with a long bole, smooth grey bark, imparipinnate leaves and dense panicles of purplish flowers found in the western ghats from S. Kanara to Travancore and Tirunelveli hills, up to an altitude of c. 1,000 m. It is a fast growing tree and is also sometimes cultivated. The wood (wt., 657 kg./cu. m.) is white and

moderately hard and though not much known, is said to be valued locally for various domestic purposes (Bourdillon, 122).

OROBANCHE Linn. (*Orobanchaceae*)

D.E.P., V, 494; Fl. Br. Ind., IV, 324.

A cosmopolitan genus of parasitic herbs more commonly distributed in the tropics and sub-tropics of the northern hemispheres. Ten species occur in India.

Orobanche (*Tokra* or *BROOM-RAPE*) are scapigerous annual or perennial root parasites, completely destitute of chlorophyll and depending for their nutrition mainly on the host plants. Of the species occurring in India *O. aegyptiaca* and *O. cernua* are the commonest, causing considerable damage to certain crops.

O. aegyptiaca Pers. syn. *O. indica* Buch.-Ham. ex Roxb. (HINDI—*Sarsan-banda, bhatua ghas, tokra*; GUJ. *Vakumba*; TEL.—*Bodu*) is a herb with bracteolate blue flowers found throughout the plains on crops belonging to the genera *Brassica*, *Cannabis*, *Solanum*, *Nicotiana*, *Papaver*, *Zea*, *Carthamus*, etc.: it is particularly common on cruciferous plants. The parasite appears as yellow succulent shoots, growing perpendicularly from the roots of the host plant. *O. cernua* Loefl. is a herb more or less similar to *O. aegyptiaca* in appearance, but has cbracteolate flowers, which are comparatively pale in colour and borne in a denser spike. It is found throughout India



Cent. Tob. Res. Inst., Rajahmundry

FIG. 47—*OROBANCHE CERNUA* VAR. *DESERTORUM*—PARASITIC ON TOBACCO

* Some authors regard *O. glabrum* as a distinct species.

ascending to an altitude of c. 4,000 m. in the Himalayas. It is more common on solanaceous plants and a variety of it, *O. cernua* var. *desertorum* Beck syn. *O. nicotianae* Wight (TEL.—*Bodu*; TAM.—*Pokayilai-kalan*) is the common parasite on tobacco plants in S. India. *O. ramosa* Linn. has been recorded from Jammu & Kashmir on hemp and lucerne; in Europe, it also attacks solanaceous crops. *O. alba* Steph. syn. *O. epithymum* DC. is a glandular hairy herb with reddish or purple brown flowers, parasitising grass and *Thymus* spp. in the Himalayas from Kashmir to Kumaun at an altitude of c. 4,000 m. [Shaw, *Mem. Dep. Agric. India, Bot.*, 1917, 9(3), 107; Mudaliar & Rao, 309; Clapham et al., 916].

Orobanche are noxious and persistent weeds, producing very small seeds (c. 184,000 seeds per grain) in large numbers. Excessive seed production coupled with their long viability (up to 10 years) and wide dispersal by wind make their control difficult. The only effective method has been their continuous removal before seeding and destruction by burning. Spraying with Crag Herbicide I (Crag Sesone), 2% solution of MCPA or 25% solution of Blue Vitriol has proved quite effective in checking their spread. *O. aegyptiaca* is readily destroyed within 9–15 days by spraying 0.001–0.1% solution of 2,4-D, 2-naphthoxyacetic acid or 1-naphthyl acetic acid: the action is so rapid that the seeds are not allowed to set. A fungus, *Sclerotinia sclerotiorum* forma *orobanchae*, has been recorded causing a wet rot of the flowering scape, without affecting the host plants [Sharma, *Allahabad Fmr.*, 1960, 34(2), 98; *Chem. Abstr.*, 1949, 43, 3134; Narasimhan & Thirumalachar, *Phytopath. Z.*, 1954, 22(4), 426].

Attempts to use *Orobanche* for fodder purposes are considered undesirable, as the seeds pass out of the alimentary canal of cattle in a viable state and help in their dispersal, when cattle manure from such animals is used. *O. aegyptiaca* is reported to be used medicinally to stop diarrhoea and as a cure for boils in the throat of cattle (Kirt. & Basu, III, 1836).

OROXYLUM Vent. (*Bignoniaceae*)

A genus of trees found in Indo-Malaysian region and China. One species is found in India.

O. indicum Vent.

D.E.P., V, 495; Fl. Br. Ind., IV, 378; Kirt. & Basu, Pl. 704.

SANS.—*Shyonaka*; HINDI—*Ullu, arlu, saona*; BENG.—*Sona, nasona, sonpatti*; MAR.—*Tetu*; GUJ.—*Aralu,*

tentu; TEL.—*Dundilum, pampini*; TAM.—*Achi, pei-arlanthei*; KAN.—*Tigdu, bune pale, sonepatta*; MAL.—*Palagapaiyani*; ORIYA—*Phapni, phonphonia*.

PUNJAB—*Mulin, tatmorang*; NEPAL & LEPCHA—*Tatola*; ASSAM—*Toguna, bhatghila, dingari*.

A small to medium sized deciduous tree, up to 12 m. in height, found throughout the greater part of India up to an altitude of 1,200 m.; it is chiefly met with in ravines and moist places in the forests and is rare in the western drier regions. Bark light greyish brown, soft, spongy; leaves large, up to 1.5 m. long, pinnate, bipinnate or tripinnate: leaflets ovate or elliptic; flowers in large, erect racemes, lurid purple, fleshy, foetid; capsules large, flat, sword shaped, up to 90 cm. x 9 cm., valves woody; seeds many, flat, thin, with broad silvery wing.

The tree reproduces naturally by seeds which germinate in the beginning of the rainy season; moderate shade is necessary in the early stages. Artificial reproduction may be done by sowing the



F.R.I., Dehra Dun
FIG. 48—OROXYLUM INDICUM—TREE IN FRUIT

OROXYLOM

seeds in the nursery during March–April and transplanting the seedlings in the first or second rainy season. The tree can also be propagated by transplanting root suckers which are produced in great profusion, often forming a dense growth round the parent stem. The rate of growth of the tree is reported to be fast, with a mean annual girth increment of 4–6.4 cm. (Troup, II, 692).

Most parts of the tree are used in medicine. The root bark is a well known drug in Ayurvedic system and is prescribed fresh. It is cream yellow to grey in colour, soft and juicy, without any characteristic odour; it has a sweet taste, later becoming faintly bitter; it has a short fracture, slightly fibrous inside. The stem bark is less juicy and less sweetish, but more leathery or tough. Entire roots are also often used, but they lose their vitality after a few months. The root bark is tonic and astringent and useful in diarrhoea and dysentery; it is diaphoretic and is used in rheumatism. Boiled in sesamum oil, it has been recommended for otorrhoea. Tender fruits are refreshing and stomachic and the seeds purgative. In Malaya, a decoction of the leaves is given in stomach ache and rheumatism; the leaves are used externally for enlarged spleen, headache and ulcers. The bark is used externally and the seeds internally in veterinary medicine (Chopra, 1958, 518, 681; Pharmacognosy of Ayurvedic Drugs, Ser. I, No. 2, 1953, 39–48; Kirt. & Basu, III, 1840; U.S.D., 1955, 1780; Burkill, II, 1591).

The stem and root barks contain three flavone colouring matters, viz. oroxylin-A (stem bark, 0.65%; root bark, 0.86%), baicalein (stem bark, 0.5%) and chrysin (stem bark, 0.35%) (Table 1). Oroxylin-A is

the 6-methyl ether of baicalein and has been synthesized. The bark contains also traces of an alkaloid, tannic acid, sitosterol and galactose (Bose & Bhattacharya, *J. Indian chem. Soc.*, 1938, 15, 311; Shah et al., *J. chem. Soc.*, 1936, 591; 1938, 1555; Sreerama Murti & Seshadri, *Proc. Indian Acad. Sci.*, 1949, 29A, 1; Row et al., *ibid.*, 1948, 28A, 189; Wehmer, II, 1137).

The seeds on extraction with petroleum ether yield c. 20% of a non-drying, bright yellow oil with the following constants: sp. gr.^{25°}, 0.9062; n^{25} , 1.4646; acid val., 0.71; sap. val., 183.9; iod. val. (Hanus), 71.5; Hehner val., 93.26; R.M. val., 0.92; Polenske val., 1.40; acet. val., 6.30; and unsapon. matter, 1.36%. The mixed fatty acids contain 80.4% oleic and 19.6% saturated acids (palmitic, stearic, and probably lignoceric and higher acids). The seeds contain a yellow crystalline principle (m.p. 274°), and baicalein and its glucoside named tetuin (baicalein-6-glucoside, $C_{21}H_{20}O_{10} \cdot 2H_2O$, m.p. 112–14°) (Mehta, *Proc. Indian Acad. Sci.*, 1939, 9A, 390; Mehta & Mehta, *Curr. Sci.*, 1943, 12, 274; 1953, 22, 114; *J. Indian chem. Soc.*, 1959, 36, 46).

Young shoots and unripe fruits are eaten as vegetables; flowers and bark are also reported to be eaten. The tree is lopped for fodder. Thin light seeds are said to be used as stuffing material for hats and umbrellas. Bark and fruits may be used as mordant in dyeing and tanning. The plant is reported to possess antiseptic properties. The wood (wt., 480 kg./cu. m.) is yellowish white and soft and may be used as fuel; it has been reported to be used for match boxes in Philippines (Burkill, II, 1591; Brown, 1946, III, 329; Laurie, *Indian For. Leafl.*, No. 82, 1945, 15; Chopra, 1958, 598; *Indian For.*, 1948, 74, 280).

TABLE 1—COLOURING MATTERS OF STEM AND ROOT BARKS*

Name and structural formula	Molecular formula	m.p.
Oroxylin-A (5:7-dihydroxy 6-methoxyflavone)	$C_{16}H_{12}O$	219–20
Baicalein (5:6:7-trihydroxy flavone)	$C_{15}H_{10}O_5$	265–66°
Chrysin (5:7-dihydroxy flavone)	$C_{15}H_{10}O_4$	274–75°

* Shah et al., *J. chem. Soc.*, 1936, 591; Bose & Bhattacharya, *J. Indian chem. Soc.*, 1938, 15, 311; Row et al., *Proc. Indian Acad. Sci.*, 1948, 28A, 189.

Orpiment — see Arsenic Ores

Orris Root — see Iris

ORTHANTHERA Wight (*Asclepiadaceae*)

A small genus of shrubs distributed in India and Africa. One species is found in India.

O. viminea Wight

D.E.P., V, 497; Fl. Br. Ind., IV, 64.

HINDI—Mahur, khip.

A bushy almost leafless shrub, 1.2–2.4 m. in height, with stems up to 3.8 cm. in diam., found in the sub-Himalayan tracts of Punjab and U.P. up to an altitude of 900 m., especially in river beds. Bark greyish white, smooth; flowers in compact woolly

cymes, dull brown ; follicles solitary, elongate ; seeds comose.

The plant yields a fibre obtained by steeping the stems in water for four or five days. Ropes made of the fibre are strong and durable. Stems can also be directly made into ropes, which do not readily rot from moisture. The flower buds are eaten as vegetable.

Orthoclase — see **Felspar**

ORTHOSIPHON Benth. (*Labiatae*)

A genus of annual or perennial herbs, undershrubs or shrubs distributed in the tropics of the Old World, mainly in Africa and extending eastwards as far as Queensland. About a dozen species occur in India.

O. spiralis (Lour.) Merrill syn. **O. aristatus** (Blume) Miq. ; **O. stamineus** Benth. ; **O. grandiflorus** Boldsingh
KIDNEY TEA PLANT, JAVA TEA

Fl. Br. Ind., IV, 615 ; Mukerjee, Rec. bot. Surv. India, 1940, 14(1), 26 ; Sleen, Reinwardtia, 1959-61, 5(1), 38.

An erect, slender, perennial shrub, 30-120 cm. high, found in Manipur, Naga and Lushai hills, Chota Nagpur, western ghats and Nicobar Islands. Leaves

ovate, acuminate, coarsely toothed ; flowers white or purplish, in lax-flowered racemes ; nutlets broadly oblong, compressed, rugulose.

The plant is grown as an ornamental for its white or purplish flowers with white projecting stamens, resembling a cat's whiskers. It is suitable for beds in shady portions of the garden and also for filling up odd corners and as a foil for more brilliant shrubs (Gopalaswamiengar, 448 : Harler, 142).

O. spiralis is mainly valued for its leaves (*Orthosiphonis folia*) used as a diuretic. Before World War II, it was cultivated for its leaves mostly in Indonesia ; it is now grown to a small extent in South Vietnam. It can be grown on a wide range of climate and soil, but thrives best under thin shade. It can serve as a remunerative catch crop in coconut or rubber plantations. The plant can be grown from seeds or by cuttings. Raised from cuttings, it gives appreciable flush of leaves in 2-3 months from the time of planting. Flowers should be removed as and when they appear as they are supposed to deprive the leaves of their active constituents. The leaves are gathered in the same way as tea at intervals of 2-3 weeks, the tender bud and the shoot with 2-4 leaves being nipped off by hand. The leaves are then withered for c. 24 hr. and dried in the sun or in hot air driers : 1.0 kg. of green leaf yields about 0.17 kg. of cured leaves. When the leaves are crisp-dry, they are crushed and immediately sifted through a wire sieve with 3 mm. square meshes. The finished product is stored in air-tight tins or packed in tea chests ready for export. There is a steady demand for the drug in Europe, where an extract from the leaves is sold in the form of a tincture or in tablets. Sun dried product is preferred to oven dried, since it is believed that high temperature destroys the medicinal properties (De Soyza, Trop. Agriculturist, 1936, 86, 210 : Steinmetz, Quart. J. Crude Drug Res., 1961, 1, 59).

The drug occurs in commerce as small, oval, finely toothed leaves, rolled up like tea. It is almost odourless and tasteless and is reported to be official in a number of Pharmacopoeias. The standard drug should contain $\geq 13\%$ moisture, $\leq 8\%$ ash, and $\leq 30\%$ water soluble extract ; the best grades yield 40-45% water soluble extract (U.S.D., 1955, 1780 ; Steinmetz, loc. cit. ; Chem. Abstr., 1941, 35, 6736).

The activity of the leaves is attributed mostly to the presence of high percentage (0.7-0.8) of potassium salts and a bitter glycoside, orthosiphonin. The leaves are reported to contain also a saponin, an alkaloid, an essential oil (0.2-0.6%), tannins, organic acids



FIG. 49—ORTHOSIPHON SPIRALIS—FLOWERING BRANCH

ORTHOSIPHON

particularly tartaric, citric and glycolic, urea, and a greenish fatty oil. The saponin yields arabinose and glucose (or fructose), besides a sapogenin. The essential oil (n_{D}^{20} , 1.4963; $[\alpha]_D^{20}$, -3.6°) is yellow in colour and has a strong unpleasant odour. The unsaponifiable matter of the fatty oil contains β -sitosterol and α -amyrin. A process has been recently patented in Germany for the extraction of an active diuretic principle (m.p. 222-24°), in a yield of 0.22% (Steinmetz, loc. cit.; Hoppe, 626; Wehmer, suppl., 141; Henry, 781; Chem. Abstr., 1934, 28, 3835; 1952, 46, 1716; 1959, 53, 18984; 1961, 55, 10814; Gildemeister & Hoffmann, VII, 104).

The drug is a highly cumulative diuretic, most useful in nephrosis and severe cases of oedema (dropsy). An infusion of the leaves is given as a specific in the treatment of various kidney and bladder diseases including nephrocirrhosis and phosphaturia; it is also used in rheumatism and gout; it renders the urine clear. The drug has the property of making the blood alkaline. The presence of orthosiphonin and potassium salts in the drug helps in keeping uric acid and urate salts in solution, and thus prevents deposits (calculi, etc.) from forming in the kidney. Leaf extract lowers the blood sugar in diabetic patients but not consistently; it stimulates glycogen formation and exerts a sympatholytic action. It is also used as a hypertensive agent (Steinmetz, loc. cit.; Kirt. & Basu, III, 1969; Chem. Abstr., 1954, 48, 13086; Hoppe, 626).

O. glaberrimus Benth. syn. *O. tomentosus* Benth. var. *glaberrimus* Hook. f. (MAL.—*Kattu-thirthava*) is an erect herb, 30-60 cm. high, found in Orissa, Gujarat and S. India, ascending up to 1,000 m. in the hills. A decoction of the plant is given to cure diarrhoea and piles; a decoction of leaves cures fever. Leaves are pounded and applied to cuts and wounds (Rama Rao, 322).

O. rubicundus Benth. (MUNDARI—*Jikipota*) is an erect shrub, 30-90 cm. high, with woody rootstock and fusiform, tuberous roots, 2.5-7.5 cm. long, found from Kashmir to Nepal and in Bihar, West Bengal, Orissa, N. Circars, Deccan and western ghats, ascending up to 1,800 m. in the hills. It comprises three or four different varieties. The tubers of the plant are said to be eaten and yield a starch. In Chota Nagpur, they are reported to be used as a remedy against colic (Hedrick, 398; Uphof, 259; Bressers, 120).

Ortolan — see Birds

*ORYGIA Forsk. (*Aizoaceae*)

A monotypic genus, represented by *O. decumbens*, distributed in India, Arabia and Africa.

O. decumbens Forsk.

D.E.P., III, 318; Fl. Br. Ind., II, 661; Flower, Pl. Sudan, I, Fig. 59.

A decumbent diffuse branched herb, 15-45 cm. high, found in warmer parts of Punjab, Rajasthan and Deccan. Leaves obovate, cuspidate, fleshy; flowers purplish green, in slender cymes; capsules pale yellow, smooth, shining; seeds reniform, black.

The leaves of the plant are eaten in times of scarcity. An infusion of the root is taken by the Zulus of S. Africa for biliousness and in larger quantities as an emetic for the same condition [Gammie, Rec. bot. Surv. India, 1902, 2(2), 182; Watt & Breyer-Brandwijk, 7].

ORYZA Linn. (*Gramineae*)

A small genus of annual or perennial swamp grasses distributed in the tropical and sub-tropical regions of Asia, Africa, America and Australia. About a dozen species have been recorded in India, including some introduced from other countries. One species, *O. sativa*, ranks as one of the world's most important food plants and is cultivated in all warm countries for the grains (Rice), which constitute the staple food of millions.

Several authors have made valuable contributions to the taxonomy of this genus. Much work has been done regarding nomenclature of the species in the genus, their distribution and contribution to the evolution of the cultivated rice. Based on a recent examination of all the type specimens available in various herbaria, 23 species have been recognized as valid, while 3 are considered invalidly published and of uncertain position. Table 1 gives the names of the species, their distribution and their chromosome number, wherever known [Camus, Philipp. agric. Rev., 1921, 14(1), 7-86; Roschevitz, Bull. appl. Bot. Pl.-Breed., 1931, 27(4), 3-133; Chevalier, Rev. Bot. appl., 1932, 12, 1014; Gustchin, Riz et Rizic., 1943, 8, 1; Chatterjee, Indian J. agric. Sci., 1948, 18, 185; Ghose et al., 9-11; Nagai, 104-13; Porteres, J. Agric. trop., 1956, 3, 341, 541; Tateoka, Bot. Mag., Tokyo, 1962, 75, 418, 455; 1963, 76, 165; Sampath, Oryza, 1962, 1, 1; Curr. Sci., 1964, 33, 205].

* Some authors consider this genus as a synonym of *Corbicula* Scop. (Flower, Pl. Sudan, I, 91).

TABLE I—SPECIES OF ORYZA, THEIR DISTRIBUTION AND CHROMOSOME NUMBER*

Name	Distribution	Chromosome number (2n)
1. <i>O. alta</i> Swallen	Central & S. America	48
2. <i>O. angustifolia</i> C. E. Hubbard	Africa (N. Rhodesia, Angola)	
3. <i>O. australiensis</i> Domin	Northern Australia (Queensland)	24
4. <i>O. barthii</i> Cheval. syn. <i>O. longistaminata</i> Cheval. et Roehr.	Tropical W. Africa, S. Africa, E. Africa, Malagasy (Madagascar)	24
5. <i>O. brachyantha</i> Cheval. et Roehr.	Tropical W. Africa, Sudan	24
6. <i>O. breviligulata</i> Cheval. et Roehr. syn. <i>O. staphii</i> Roschev.	Tropical W. Africa, Sudan, Tanganyika	24
7. <i>O. coarctata</i> Roxb.	South-East Asia, India (Sundarbans, Godavari & Cauvery delta), Burma	48
8. <i>O. eichingeri</i> A. Peter syn. <i>O. latifolia</i> Hook. f. var. <i>collina</i> (Trimen) Hook. f.	E. & Central Africa, Ceylon	48
9. <i>O. glaberrima</i> Steud.	W. Africa (cultivated)	24
10. <i>O. grandiglumis</i> (Doell) Prod.	S. America (Brazil, Peru, Colombia, Fr. Guiana)	48
*11. <i>O. jeyaporensis</i> Govindaswami et Krishnamurthy	India (Orissa)	24
12. <i>O. latifolia</i> Desv.	Central & S. America, W. Indies	48
13. <i>O. longiglumis</i> Jansen	New Guinea	..
14. <i>O. meyeriana</i> (Zoll. et Mor. ex Steud.) Baill. subsp. <i>meyeriana</i>	South-East Asia (Java, Borneo, Philippines, Thailand)	24
subsp. <i>granulata</i> (Nees et Arn. ex Watt) Tateoka	South-East Asia (Burma, Indo-China, Thailand, Java, Sumatra, S. China) including India (Assam, Bengal, Sikkim, Madras) & Ceylon	24
subsp. <i>abromeitiiana</i> (Prod.) Tateoka	Philippines, Moluccas	..
15. <i>O. minuta</i> J. S. Presl ex Presl	Philippines, Malaya, Indonesia	48
16. <i>O. officinalis</i> Wall. ex Watt subsp. <i>officinalis</i>	South-East Asia including India (Assam, Sikkim)	24
subsp. <i>O. malampuzhaensis</i> (Krishnaswamy et Chandrasekharan) Tateoka	South India	48
17. <i>O. perennis</i> Moench emend. Sampath	Tropical Asia, Africa, America	24
18. <i>O. perrieri</i> A. Camus	Malagasy (Madagascar)	..
19. <i>O. punctata</i> Kotschy ex Steud.	Tropical Africa, Malagasy (Madagascar)	
20. <i>O. ridleyi</i> Hook. f.	South-East Asia (Burma, Malaya, Thailand, Indo-China, Sumatra, Borneo, New Guinea)	48
21. <i>O. rufipogon</i> Griff. syn <i>O. fatua</i> Koenig ex Trin.; <i>O. sativa</i> forma <i>spontanea</i> Roschev.; <i>O. glumaepatula</i> Steud.	Tropics & sub-tropics of Asia (India, E. Pakistan, Burma, Ceylon, Thailand, Indo-China, Formosa, Philippines, Malaya, Indonesia, New Guinea), N. Australia, America (W. Indies, Venezuela, Colombia, Ecuador, Brazil)	24
22. <i>O. sativa</i> Linn. syn. <i>O. plena</i> (Prain) Chowdhury	Cultivated throughout warmer parts of the world	24
23. <i>O. schlechteri</i> Pilger	New Guinea	
*24. <i>O. subulata</i> Nees	S. America (Brazil, Paraguay, Uruguay)	24
25. <i>O. tisseranti</i> Cheval.	Tropical Africa	..
*26. <i>O. ubangensis</i> Cheval.	W. Africa	

*Tateoka, Bot. Mag., Tokyo, 1963, 76, 165. ** Considered invalidly published or of uncertain application.

ORYZA

Since the publication of Roshevitz's classification, the minute details of glume structure, silicification of epidermal cells, as well as the presence or absence of hairs have been utilized for identification of the taxa. In order to understand the evolution of species and their present distribution, other characters have also been taken into account such as the habit of the plant, features of the grain and endosperm, physiological characters like seed dormancy, sensitivity to photoperiod and disease resistance; such studies are being supplemented by cytogenetic studies of inter-specific crosses for tracing relationships and differentiation of the various species.

Of the species of *Oryza* enumerated above, two, viz. *O. sativa* and *O. glaberrima* are cultivated, the former including the common rice cultivated all over the world and the latter grown to a limited extent in Africa; all the other species are found wild in different parts of the world. Of these wild species,

about 9 are endemic to Africa and 6 to India; only one, viz. *O. perennis* is of world-wide distribution.

There has been considerable discussion regarding the inter-relationship among the species in the genus, particularly with reference to their role in the evolution and origin of cultivated rice. According to some, the two cultivated species of rice, viz. *O. sativa* and *O. glaberrima* are considered to have evolved by human selection from one primitive, cosmopolitan and variable species, probably *O. perennis*, while according to others they have evolved independently from two wild progenitors, *O. sativa* from *O. perennis*, an Asian species and *O. glaberrima* from *O. breviligulata*, an African wild species. In this connection, it has been pointed out that to postulate independent origin of rice in two continents is extraordinary and that the two cultivated species, though showing certain taxonomic differences and considerable sterility when crossed, show so many resemblances that



Cent. Rice Res. Inst., Cuttack. Photo : S. Sampath

FIG. 50—SPIKELETS OF WILD SPECIES OF ORYZA IN INDIA

1. *O. coarctata* ; 2. *O. rusipogon* ; 3. *O. glaberrima* ; 4. *O. perennis* ; 5. *O. officinalis* subsp. *malampuzhaensis* ;
6. *O. meyeriana* ; 7. *O. officinalis* subsp. *officinalis*

a plausible case can be made even to group them as a single species (Ramiah & Ghose, *Indian J. Genet.*, 1951, 11, 7; Sampath & Rao, *ibid.*, 1951, 11, 14; Richharia, *ibid.*, 1960, 20, 1; Grist, 3; Morishima *et al.*, *Evolution*, 1963, 17, 170).

Based on morphological, cytogenetical and phyto-geographical studies, the species of *Oryza* can be grouped into three sections, viz. (1) SATIVA including the two cultivated species *O. sativa* and *O. glaberrima*, as well as wild species related to them ; (2) OFFICINALIS comprising species resembling *O. officinalis* in having large panicles, small, flattened, densely hairy seeds ; and (3) GRANULATA consisting of species of uncertain affinity, perennial in habit, and having partly or fully glabrous, terete seeds (Richharia, *Indian J. Genet.*, 1960, 20, 1).

Closely connected with this problem of origin of cultivated rice is the question, whether the first cultivated plant was an upland plant growing without any standing water or a lowland plant growing under marshy conditions. It has been suggested that man invented wet cultivation as pressure on land increased, after he had grown rice for a long period as an upland crop. Primitive agriculture, usually associated with shifting cultivation, is an upland practice both in South-East Asia and Africa, where evolution of cultivated rice must have taken place along parallel lines. As against this view, is the suggested origin of cultivated rice as a lowland plant from *O. perennis*, a plant loving wet conditions. This contradiction can be reconciled by the fact that even in upland areas of monsoon lands in Bengal, Assam and Burma, the water is copious for 3-5 months and therefore the water loving *O. sativa* is the only crop suitable for growth in these areas and in the river basins of tropical Asia. Further, the upland rices are generally of short duration and insensitive to changes in the natural photoperiods of the tropics ; they are also adapted to drained soils, which never suffer from oxygen deficit or reducing conditions. Both these characters can be inferred to be rather advanced or evolved from the swamp rices (Burkill, II, 1595 ; Jordon, *Curr. Sci.*, 1962, 31, 269).

According to some, there is no convincing evidence whether upland and lowland rices have developed from a single progenitor or from different progenitors. It is considered that diversification of plant types could have proceeded in different directions, from wild rice to long stemmed floating rice for deep water conditions, and to typical short stemmed rice suitable for lowland and upland conditions (Nagai, 124-25).

O. coarctata Roxb.*

D.E.P., V, 498 ; C.P., 823 ; Fl. Br. Ind., VII, 93.

A coarse stout grass with spinous-serrate leaves found in the lower Gangetic basin in Sundarbans, in the estuaries of Mahanadi in Orissa and in Godavari delta in Andhra Pradesh. It is essentially an aquatic plant, frequenting margins of rivers and tidal swamps and adapted to salinity in the soil. It has been recorded also from Indus delta in West Pakistan and Irrawaddy delta in Burma.

The grain resembles wheat and is said to be edible ; the rice has a soft chalky texture. The nutritive ratio was found to be 7.6 (Rice in Orissa, 191 ; Ghose *et al.*, 10).

O. meyeriana (Zoll. et Mor. ex Steud.) Baill. syn. *O. granulata* Nees et Arn. ex Steud.

D.E.P., V, 500 ; C.P., 823 ; Fl. Br. Ind., VII, 93 ; Fl. Assam, V, 172.

A perennial grass, up to 1.0 m. high, with a compact and small rootstock found in the foothills of eastern India, Bengal, Bihar, Orissa and Madras and extending further south in South Asia. It bears short erect panicles with awnless spikelets, 5-6.5 mm. x 2.5 mm., glabrous, pale green or greyish in colour. According to some authors the Indian plant, *O. granulata* is quite distinct from the Indonesian *O. meyeriana*. Recent taxonomical studies indicate that the Indian plant may be considered as a separate sub-species [Backer, *Blumea*, 1946, 3, suppl., 45 ; Govindaswami & Krishnamurthy, *Rice News Teller*, 1959, 7(1), 9 ; Sampath, *Bot. Mag., Tokyo*, 1961, 74, 269 ; Tateoka, *ibid.*, 1962, 75, 455 ; 1963, 76, 165].

This species is generally found in well drained soils at altitudes up to 1,000 m. or along streams under shade. The grains have a good flavour and the grass is eaten by cattle (Haines, V, 981 ; Mooney, 167 ; Bor, 1960, 604).

O. officinalis Wall. ex Watt syn. *O. latifolia* Hook. f. (Fl. Br. Ind.) non Desv.

D.E.P., V, 501 ; C.P., 824 ; Fl. Br. Ind., VII, 92 ; Fl. Assam, V, 171.

A tall annual or perennial grass with sub-woody roots occurring in Assam, Khasi hills and Sikkim Terai in eastern India and Maharashtra in western India. Culms tufted, with broad multi-nerved leaves and profusely branched panicles ; spikelets elliptic,

* Based on unique features of the embryo, morphology and leaf anatomy, this species is referred back to the genus *Sclerophyllum* Griff. which is revived for it (Tateoka, *Amer. J. Bot.*, 1964, 51, 539).

3.5–5.5 mm. long and more than 2 mm. broad ; awns, when present, less than 2.5 cm. long.

This species was originally confused with *O. latifolia* Desv., which is purely tropical American. Some authors consider *O. officinalis* as conspecific with *O. minuta* J. S. Presl ex Presl, a species known at present only from Philippines, but which is a tetraploid. Recent analysis of the characters of the two species indicates that they can be separated by morphological, cytological and phytogeographical standpoints (Bor, 1960, 605; Sampath, *Bot. Mag., Tokyo*, 1961, 74, 269; Tateoka, *ibid.*, 1962, 75, 418; 1963, 76, 165).

A new tetraploid species, *O. malampuzhaensis* Krishnaswamy et Chandrasckharan, recently described from Anaimalai hills (Madras State), is similar to *O. officinalis* but can be separated from it by hairy ligules, longer spikelets, as well as tetraploidy. It has been assigned to this species as a sub-species, since the morphological distinction between them is not marked (Krishnaswamy & Chandrasckharan, *Madras agric. J.*, 1958, 45, 471; Tateoka, *Bot. Mag., Tokyo*, 1962, 75, 418; 1963, 76, 165).

This grass is reported to be eaten by cattle (Bor, 1960, 605).

O. perennis Moench emend. Sampath syn. *O. longistaminata* Cheval. et Roehr.; *O. barthii* Cheval. in part; *O. sativa* var. *bengalensis* Watt

Chatterjee, *Indian J. agric. Sci.*, 1948, 18, 185; Sampath, *Curr. Sci.*, 1964, 33, 205.

A water loving, potentially perennial plant, with creeping or bulbous rhizomes and erect or prostrate culms, sometimes floating ; leaves broad, 10–20 mm. wide with long acute ligules ; panicles medium sized ; spikelets deciduous, slender and about 9 mm. long and 2–3 mm. wide, with awns 7–10 cm. long.

This species is considered polymorphic and widely distributed in tropical Africa, America and Asia. In India, it has been reported from Orissa, Bengal and Assam. Other Asiatic records are from Burma, Indonesia and Formosa. It includes two distinct populations, one strongly rhizomatous and erect growing, found in Africa and classified by some as a distinct species, *O. barthii*, and the other a weakly rhizomatous and spreading or floating plant found in Asia and classified as *O. longistaminata*. The American plant which has a semi-erect habit has been designated as *O. perennis* var. *cubensis* Sampath. It has been pointed out that the breeding system of *O. perennis* is quite suitable for accumulating genetic variations, as they are partly cross-pollinating and partly vege-

tatively propagating and the seeds remain dormant for long periods. According to some, *O. perennis* with its several geographical races represents the common ancestral type from which all cultivated rices are derived, viz. *O. sativa* in Asia and *O. glaberrima* in Africa. Some authorities hold that the African populations are quite distinct and deserve a separate specific status and have not contributed directly to the origin of *O. glaberrima*. The original description of *O. perennis* Moench is incomplete and the correct application of the specific name has been uncertain. Consequently an amended diagnosis of the species based on material collected in Orissa has been recently published (Sampath & Rao, *Indian J. Genet.*, 1951, 11, 14; Richharia, *ibid.*, 1960, 20, 1; Ghose *et al.*, 11; Sampath, *Bot. Mag., Tokyo*, 1961, 74, 269; Tateoka, *ibid.*, 1963, 76, 165; Hinata & Oka, *Jap. J. Genet.*, 1962, 37, 329; Sampath, *Curr. Sci.*, 1964, 33, 205).

The grains are edible and are occasionally harvested ; they are slender and shed easily.

O. rufipogon Griff. syn. *O. fatua* Koenig ex Trin.; *O. sativa* var. *rufipogon*, *coarctata*, and *abuensis* Watt; *O. sativa* var. *spontanea* Roschew.; *O. sativa* var. *fatua* Prain; *O. glumaepatula* Steud.

D.E.P., V, 504; C.P., 824; Fl. Br. Ind., VII, 92 (in part); Bor, 1960, 605.

BENG.—*Uri, jhara*; TEL.—*Nirvari, nivaru*.

MADHYA PRADESH—*Karga*.

An annual growing in water or swampy places in Assam, West Bengal, Chota Nagpur, Madhya Pradesh, Orissa and eastern parts of Andhra Pradesh, with long erect culms, nearly 2 m. long, and deciduous spikelets, nearly 7 mm. long and having an awn, rather rigid.

Under this species are included the major portion of the wild rice populations which are often found growing as a weed in the fields of cultivated rice and on margins of tanks. It is widely distributed in tropics and sub-tropics of Asia, America and northern Australia ; its sporadic occurrence in West Africa is also known. According to some the S. American plants which have longer spikelets and longer awns may belong to a distinct species (*O. glumaepatula* Steud.).

O. rufipogon is very much like cultivated rice in vegetative characters ; because of its vigorous and aggressive mode of growth it becomes a noxious weed. It is distinguished from cultivated rice by the shattering of its grains long before they ripen. The grains are marked by their reddish stout awns and range

in colour from red to white or almost black. They are gathered by tying the plants together in clumps and the sparse harvest is used in parts of Madhya Pradesh on fast days. Because of its coarse foliage, it is not acceptable as fodder by cattle, but buffaloes eat it (Bor, 1960, 605; Ghose *et al.*, 11; Tateoka, *Bot. Mag., Tokyo*, 1962, 75, 455; 1963, 76, 165; Roy, *Agric. J. India*, 1921, 16, 365).

This species is highly polymorphic and considered to be the most closely related to cultivated rices, *O. sativa*, with which it hybridizes freely. Its distribution in South-East Asia coincides with the areas of most ancient cultivation of rice and the enormous diversity existing among cultivated rices in India is attributed to this species. It is probably the source of the red coloured rices of India. It is stated that unlike other wild species it does not show heavy spotting (leaf infestation) due to *Helminthosporium oryzae* or by *Piricularia oryzae* (Hutchinson & Ramiah, *Indian J. agric. Sci.*, 1938, 8, 592; Ramiah & Ghose, *Indian J. Genet.*, 1951, 11, 7).

A difference of opinion prevails regarding specific limitations of this species. According to some recent authors, the floating perennial rice of Asia erroneously included under *O. fatua* should be designated as *O. perennis* Moench and the annual bold seeded wild rice occurring as a weed in rice fields should be considered as of more recent hybrid origin, arising by introgressive hybridization of the perennial Asiatic *O. perennis* with cultivated *O. sativa*. In support of this inference it is stated that not only are wild rices collected from Orissa proved to be heterozygous, but their morphological and genetical features indicated their hybrid origin. Further confirmation to this interpretation was available from artificial crosses made of Indica rices with *O. perennis* occurring in Orissa. It is suggested, therefore, that these wild rices of hybrid origin are preferably called Spontanea rices, signifying their occurrence in nature. Evidences for possibility of such Spontanea rices having developed independently in Asia, Africa and America have also been advanced (Sampath & Rao, *Indian J. Genet.*, 1951, 11, 14; Richharia, *ibid.*, 1960, 20, 1; Sampath & Govindaswami, *Rice News Teller*, 1958, 6(3), 17; Ghose *et al.*, 11; Sampath, *Curr. Sci.*, 1964, 33, 205).

O. sativa Linn. syn. *O. plena* (Prain) Chowdhury RICE, PADDY

D.E.P., V, 502; C.P., 824; Fl. Br. Ind., VII, 92.

SANS.—*Dhanya, vrihi, nivara, syali*; HINDI—*Dhan*,

chaval; BENG.—*Chal*; MAR.—*Tandula, dhan, bhat*; GUJ.—*Dangar, choka*; TEL.—*Vadlu, varidhanyamu, biyyamu*; TAM.—*Nellu, arisi*; KAN.—*Nellu, bhatta, akki*; MAL.—*Nellu, ari*.

An annual or perennial grass without a rhizome; leaves long and narrow, 30–50 cm. × 1.2–2.5 cm., slightly pubescent with spiny hairs on the margin; inflorescence a terminal panicle varying from close and compact in some to loose and spreading in others; spikelets generally single, but in some in clusters of 2–7; number of spikelets varying from 50–60 to 200–300, large numbers being usually associated with smaller size and a densely packed arrangement; lemma and palea surrounding the kernel, variously coloured, golden yellow, red, purple, brown or smoky black, becoming straw or light yellow when the grain ripens; grain varying in size from 5 to 14.5 mm. long and 1.9 to 3.7 mm. broad, the length/breadth ratio defining size and shape of the grain; kernel most commonly white, occasionally red, purple or brown.

Rice is one of the oldest of food crops and has been in cultivation in India, China, Java and East Africa from very ancient times. There are records of rice in ancient Hindu scriptures and literature of India, some of them dating back to 1,300 B.C. Carbonized paddy grains and husks have been found in the excavations at Hastinapur (Uttar Pradesh) dated 1,000–800 B.C. and more recently impressions of paddy on clay lumps and remnants of husk have been found in Lothal in Gujarat, which is considered to be a southward extension of the Harappa and Mohenjodero culture of Indus Valley civilization assigned to c. 2,300 B.C. (Ramiah, 1; Ramiah & Rao, 4; Chowdhury & Ghosh, *Sci. & Cult.*, 1953–54, 19, 207; Ghosh, *Indian For.*, 1961, 87, 295).

Whether rice was introduced into China from India or whether it existed there at the same time as in India cannot be accurately determined. The available evidence does, however, appear to show that rice might have originated in India or some part of South-East Asia and was introduced to China from there. One of the criteria for determining the centre of origin is the prevalence of wild relatives of the cultivated species in that region. It has been established that wild rices are common in India, while they are rarer in China and have been recorded only from South China. India and particularly South India could have been the original home of rice, for there occur in this region marshy expanses, intervening mountains and periodical inundations which are the

optimum conditions for growth of rice plants. Available information supports the inference that *O. sativa* evolved in South-East Asia (India or Indo-China), where agriculture is ancient and conditions favour diversification and mutation (De Candolle, 385; Roschevitz, *Bull. appl. Bot. Pl.—Breed.*, 1931, 27, 3-133; Ramiah, 2; Ramiah & Rao, 4-5).

Rice has long been cultivated in India and it can therefore be considered as the native home of rice; this is supported not only by the presence of a number of wild rice species, but also of intermediate forms connecting wild rice with the cultivated rice. The varietal diversity of cultivated rice in India can be considered to be the richest in the world, the coarse-grained primitive varieties being specifically typical. India differs from China and other secondary regions of cultivation by the presence of dominant genes in its varieties. Exploration of key regions in India has been suggested to provide valuable breeding material. Investigations in Jeypore tract, Orissa have shown that rice cultivated by the hill tribes at elevations of 500-1,000 m. includes a large varietal diversity, though there has been no large scale introduction of rice types into this area from outside. Hundreds of distinct types with considerable morphological and physiological variations are grown by the hill tribes within a district and they have been found to be of great genetical value. An analysis of this hybrid population has shown that it contains the whole range of variation from the wild, perennial rices of *O. perennis* through various stages of Spontanea rices, to cultivated Indica and Japonica rices, thus supporting the postulation that *O. perennis* is probably the progenitor of all cultivated rices and that introgressive hybridization has played a major role in their evolution [Ramiah & Ghose, *Indian J. Genet.*, 1951, 11, 7; Sampath & Rao, *ibid.*, 1951, 11, 14; Ramiah *et al.*, *Emp. J. exp. Agric.*, 1952, 20, 161; Vavilov, 29; Ghose *et al.*, 13; Sampath & Govindaswami, *Rice News Teller*, 1958, 6(3), 17; Govindaswami & Krishnamurthy, *ibid.*, 1959, 7(2 & 3), 12; Morishima *et al.*, *Evolution*, 1961, 15, 326; Oka & Chang, *ibid.*, 1961, 15, 418; *Bot. Bull. Acad. sinica*, 1962, 3, 109; Hinata & Oka, *Jap. J. Genet.*, 1962, 37, 329].

CULTIVATED RICE

Sub-species and their distribution—Because of the long period during which cultivated rice has been grown under varying conditions of environment, the species *O. sativa* is made up of a mass of complex forms showing large variations in morphological and

physiological characters. Based on hybrid sterility, which is an important criterion in differentiating species, *O. sativa* has been classified into two sub-species, *O. sativa* subsp. *indica* Kato and *O. sativa* subsp. *japonica* Kato*. While the former is grown all over the tropics, the latter is generally confined to temperate and sub-tropical regions beyond 30°N and S latitudes. In addition to the high spikelet sterility shown by the hybrids between the two, the two groups differ in morphological and several physiological features including response to temperature and day length. The two groups must, however, be deemed to be a single species, but due to ecological adaptation to different climatic zones, their differentiation as sub-species is clear cut. China grows both Indica and Japonica rices, the former extensively to the south of Yangtze and the latter to a limited extent only in the north. Since the Japonica rices are adapted to the extra-tropical regions with adequate water supplies, their present distribution is understandable. The Chinese and Japanese investigators have postulated that Japonica sub-species arose from Indica in Central China (Honan) and was later introduced to North China and thence to Korea and Japan. In contrast, a hypothesis has been advanced that the sterility barrier seen between Indica and Japonica could not have arisen after slow evolution of the northern types, but an introgression of a race or sub-species of *O. perennis* (from Taiwan) might have resulted in a differentiated genome, adapted to the new climatic zone [Ramiah & Rao, 10; Porteres, *J. Agric. trop.*, 1956, 3, 341, 541; Nagai, 133; Sampath & Seetharaman, *Rice News Teller*, 1962, 10(1), 17].

By continuing the work on hybrid sterility, some workers have shown that the Indica group of earlier workers includes a third group, Javanica (Indo-Japonica), consisting of rices (*Bulu*) which exhibit affinities of an intermediate nature between Indica and Japonica. Detailed work on the genealogy of a wide collection of cultivated rices has shown that as a rule, Indica rices are slow in germination, have more of long than broad grains, are late in maturity and weak in straw, while the Japonica rices have characters opposite to the above. Several other differences between Japonica and Indica rices have also been established, as for example amylose content, ability to germinate under low temperature, rate

* According to rules of nomenclature this should be designated as *O. sativa* subsp. *sativa*, but for the sake of clarity the term *japonica* is used throughout in the present work following the suggestion of Porteres (*J. Agric. trop.*, 1956, 3, 368, 541).



I.A.R.I., New Delhi

FIG. 51—PANICLES OF *ORYZA SATIVA* SUBSP. *INDICA*, SUBSP. *JAPONICA* AND SUBSP. *JAVANICA*

of respiration of young plants, reaction to phenol, etc. The Javanica rices, in contrast to these two, have tall plants with poor tillering capacity, long panicles with awned spikelets and coarse grain. Elaborate genetical and ecological studies on cultivated rice types collected from different regions have also been made regarding their reaction to temperature changes, soil fertility as revealed by tillering and lodging of straw, manurial response and to diseases and insect pests. Based on these comparative studies, it is evident that these three groups of cultivated rices are easily distinguishable though the differences are not obvious. The centres of distribution of these groups are respectively Japan, India and Indonesia. While the Indica group is rich in diversity of forms with morphological and ecological variations, there is a similar but less diversity in Japonica and comparatively little in Javanica [Nagamatsu, *Jap. J. Bot.*, 1943, **19**, 47, 249; Morinaga, *Jap. J. Breed.*, 1954, **4**, 1; Nagai, 133-41, 163-64; Sampath & Seetharaman, *Rice News Teller*, 1962, **10**(1), 17; Matsuo, *Bull. nat. Inst. agric. Sci. Japan, Ser. D*, 1952, **3**, 1-112].

Based on genetical analysis of different types selected at random from a large collection of rices all over Asia, it has been shown that the geographical groups suggested above closely correspond with groupings based on ecological and adaptational factors. The three sub-species, Indica, Japonica and Javanica (Indo-Japonica) approximate closely with

groups designated by some authors as Continental, Temperate Insular and Tropical Insular respectively. Similarly it has been pointed out that the Indica rices are generally adapted to monsoon lands, while the Japonica rices are adapted to temperate and the Javanica to equatorial climates [Nagai, 104; Oka, *Indian J. Genet.*, 1958, **18**, 79; Richharia, *Span.*, 1961, **4**(1), suppl., 1-39].

On morphological basis and sterility data in crosses, Indica and Javanica are considered distinct, the latter being similar to Japonica in their hybrid affinity and adaptation to the short day conditions of the tropical region. However, Javanica could not have arisen from Japonica and must be considered an independent differentiation of Indica in Indonesia. An alternate possibility is that Javanica sub-species has also arisen by introgressive hybridization with a local form of *O. perennis*. Their main distinctive ecological feature is low sensitivity to photoperiod, enabling a crop to be raised in any part of the year.

The Japanese rices now grown in temperate zones may be traced back genealogically to the *Aus* rice in tropical Asia. It may be mentioned that the *Aus* rices of East Pakistan form a distinct group which have a very short maturation period of about 100 days and are generally insensitive to photoperiod. The results of *Aus* × Japonica crosses show comparatively less sterility, somewhat similar to Javanica × Japonica, leading to the conclusion that the *Aus* rice might be a differentiation of Indica, which may have given rise to Japonica rices later. The early maturing rices grown in South China may also belong to this group. This allows the postulation of two differentiating centres of origin, one in the north-eastern Indian sub-continent, and another in Java near the Equator leading to Javanica rices. A fourth group intermediate between Indica and Javanica rices and known as *Gundil* has been identified in Indonesia, showing much less sterility than the bulk of the Indica rices when crossed with Japonica rices. They can be considered to represent an intermediate stage in speciation between Indica and Javanica, just as the *Aus* rices represent the intermediate stage between Indica and Japonica. Evidently genetic differentiation in Indica is still going on and the progress in plant breeding to produce improved types of rice is making the position more and more complex.

The areas which grow Japonica exclusively are Japan, S. Korea and N. China in Asia, New South Wales in Australia, Italy, Spain, France and Portugal

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in Europe, California in U.S.A. and countries of S. America below 30° latitude; in Egypt and Taiwan more productive Japonica or hybrid selections have largely replaced Indica. Cultivation of Indica is confined to areas between 0° and 25° latitude, especially South-East Asia, where intensive manuring is not practised [Nagai, 139-41; Morinaga, *Jap. J. Breed.*, 1955, 5, 149; Govindaswami & Krishnamurthy, *Rice News Teller*, 1958, 6(4), 22; Hamada in Kihara, II, 308; Sampath, *Oryza*, 1962, 1, 1].

Varietal classification—Varietal diversity of *O. sativa* is great and several thousand types differing from one another in morphological and physiological characters exist under cultivation in different parts of the world. Such diversity has arisen both by transfer of types from one geographical range to another, and by crosses between types resulting in new genetical recombinations. The numerous cultivated rices in India have been classified variously on the basis of such agricultural characters, like season of growth and period of maturity and further on morphological characters. But it is known that season and maturation period can be considerably modified by change in environment and classification on morphological basis is often confusing. The only classification that has proved of some value is that based on the size and shape of the grain. Since grain size and shape are comparatively less influenced by environment, and since they are related to the milling quality, some of the rice exporting countries such as Burma and Thailand have adopted this classification and it is recognized by the trade (Mitra & Ganguli, *Indian J. agric. Sci.*, 1932, 2, 571; Hector & Sharngapani, *ibid.*, 1934, 4, 1; Kashi Ram & Sarvayya, *ibid.*, 1934, 4, 642; Sethi & Saxena, *Mem. Dep. Agric. India, Bot.*, 1930, 18, 149; Beale, *Bull. agric. Res. Inst. Pusa*, No. 167, 1927).

Because of the large area and the large quantity coming into markets for trade within and between States in this country, it has been considered that a trade classification and standardization of rice varieties on an all-India basis would be of some value. A classification recently proposed on the basis of grain size, shape and volume is given in Table 2. It is confined to the non-scented and non-glutinous rices with white kernel, which represent the bulk of commercial rices coming into the market [Vachhani *et al.*, *Rice News Teller*, 1962, 10(1), 15].

Any simple botanical classification of these rices which has been done hitherto is said to be of little utility. To be satisfactory, the classification should

TABLE 2—CLASSIFICATION OF INDIAN RICE (IN HUSK)*

Grade	Shape index Length/Breadth	Volume of 1,000 grains in c.c.	Remarks
Oval fine	<3	up to 16.5	Small, slender grains
Oval medium	<3	17-21	Short, plump grains
Oval bold	<3	21.5 & upwards	do.
Elongated fine	>3	up to 16.5	Long, slender grains
Elongated medium	>3	17-21	Long, medium grains
Elongated bold	>3	21.5 & upwards	Long, bold grains
Very fine elongated	>4 and length >9 mm.	do.	Very long grains

* Vachhani *et al.*, *Rice News Teller*, 1962, 10(1), 15.

contain information on genetical make up in addition to botanical and field characters. A system whereby various plant characters are to be described, using prescribed tables and schedules was adopted in this country in 1938. These tables have been utilized and schedules have been widened and improved for the preparation of a World Catalogue of Rice Genetic Stocks by the FAO, which brings together all the information required of any stock (Hutchinson & Ramiah, *Indian J. agric. Sci.*, 1938, 8, 592; Ramiah & Rao, 10-13; *World Catalogue of Genetic Stocks, 2. Rice*, Suppl. No. 1-7, 1951-59, FAO, Rome).

CROP IMPROVEMENT

The total number of named types of rice in India runs to 5,000-6,000. They exhibit wide diversity in their morphological as well as physiological characters. There are rices with grains varying in colour from yellow or straw to red, purple or brown and in size from 5 mm. to 15 mm. in length and 1.9 mm. to 3.5 mm. in breadth. There are also scented and glutinous rices. It is quite possible that there are many duplicates—the same rice growing under different names—and occasionally distinct rices going under the same name in separate areas. Selection and breeding of improved types have been directed mainly towards exploiting the large variability present among them and isolating and developing from them types with economically useful characteristics, particularly high yielding types suited to the various rice growing zones in the country. Breed-

ing has also been carried on to evolve types endowed with one or more characters like earliness, resistance to floods, salinity, drought, lodging or diseases, high nutritional quality, etc. The selection methods employed have been mass selection, pure line selection and hybridization based on a fundamental study of the botanical and agricultural features of the rice plant and its wild relatives, their cytological make up and genetical behaviour. A brief summary of the work done under these aspects is given in the following paragraphs. Table 3 gives some of the important commercial varieties in different States and the improved selections made from them (Ramiah & Rao, 36-43; Ramiah *et al.*, *Emp. J. exp. Agric.*, 1952, **20**, 161; Ghose *et al.*, 108-12).

Cytology—The chromosome number of all the species of *Oryza* studied so far is $2n=24$ or $2n=48$. Cultivated species of *Oryza* have $2n=24$ chromosomes, and the tetraploid species, unlike in wheat and barley, are of no economic importance. The basic chromosome number of the genus is $n=5$ and cultivated rice is now regarded as a secondarily balanced tetraploid. Haploids with 12 chromosomes have been isolated, but they are stunted and sterile and can only be maintained by vegetative propagation. Triploids have also arisen spontaneously in nature and allotriploids have been obtained by crossing cultivated rice with a tetraploid species. These are all sterile. Many instances of autotetraploids arising spontaneously are known in *O. sativa*. Tetraploids have also been produced by colchicine treatment of shoot primordia and from hybrids between different rice varieties. Partially sterile hybrids have been obtained between Japonica and Indica rices and allotetraploids have been produced from such inter-racial hybrids (Ramiah & Rao, 257-71; Ghose *et al.*, 151-55; Grist, 72, 86).

Genetics—The rice plant offers a wealth of material for genetical studies and considerable knowledge has accumulated, largely due to work in India and Japan. While some knowledge has been gained about the genetics of morphological, quantitative and physiological characters, it is felt that more has to be learnt before it can be put to effective use in a breeding programme to synthesize economically valuable new types of rice. The genes whose inheritance has been studied have to be located to their respective chromosomes. With 12 pairs of chromosomes almost all the genes have been accounted for. The International Rice Commission has recently approved a system of gene symbolization in rice which was originally

prepared by workers in India (Ramiah & Rao, 229-46; Ghose *et al.*, 148-50; Nagai, 282-88, 374-76; Kadam & Ramiah, *Indian J. Genet.*, 1943, **3**, 7; Nagao, *Advanc. Genet.*, 1951, **4**, 181; Richharia *et al.*, *Euphytica*, 1960, **9**, 122).

The presence or absence of anthocyanin pigment in different parts of the plant is said to be often related to such valuable economic characters like the life period of the plant, the amount of spikelet sterility, the size and weight of grain, etc. The inheritance follows the same pattern in all the three sub-species, Indica, Japonica and Indo-Japonica, though the same gene loci may not be concerned in Indica and Japonica (Ramiah & Rao, 104-10).

Floating habit has been shown to be a double recessive to the normal habit and is independent of plant height. The procumbent habit is usually associated with many of the wild rices. The procumbent habit, the open habit and the compact habit form a multiple allelic series. The non-lodging strong straw which is characteristic of some varieties is usually associated with compact habit. Varieties belonging to Japonica and Indo-Japonica groups possess somewhat stronger straw than Indica rices. It is expected that some of the hybrids of Indica \times Japonica will give derivatives with strong straw (Ramiah & Rama-swamy, *Indian J. agric. Sci.*, 1941, **11**, 1; Ramiah & Rao, 111-12).

The maturation period is controlled by multiple genes and Japanese workers have postulated the presence of up to 6 genes. The varying maturation period associated with different rices grown under identical conditions is due to their genic composition. There is said to be no genetic association between maturation period and level of production (Ramiah & Rao, 178-84; Nagai, 327-40).

Factors involved in the importance of photoperiodic response have been studied in Ceylon. It is stated that a monohybrid segregation of the main gene is indicated and the wide variation in degrees of sensitivity seems to indicate a series of alleles, with possibly modifiers at other loci (Chandraratna, *New Phytol.*, 1954, **53**, 397; *J. Genet.*, 1955, **53**, 215).

Grain shattering is dominant over non-shattering and not more than 2-3 genes control the character. Progenies with no grain shattering can be derived from crosses between Indica and other rices. Investigations in Japan are said to indicate, however, that non-shattering is a simple dominant over shattering. A polygenic interpretation appears also plausible (Ramiah & Rao, 191-96; Nagai, 363-64).

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TABLE 3—SOME IMPORTANT COMMERCIAL VARIETIES OF RICE IN INDIA AND SOME IMPROVED TYPES DERIVED FROM THEM*

ANDHRA PRADESH	Akkullu (Mtu-1 & 2), Atragadalu (Mtu-6 & 14), Bangarutheegalu (Akp-9), Basangi (Mtu-3 & 4), Bikirisannalu (Slo-11), Bontha Basangi (Slo-7), Bobbiliganti (Akp-1), Delhi Bhogalu (Mtu-13), Carikasannavarai (Mtu-9), Gorti Basangi (Slo-9), Guntur Sannalu (Akp-3), Guttikusumalu (Mtu-7), Kaisipichoody (Slo-16), Kodibudumalu (Mtu-17), Kodijillamalu (Mtu-18), Konamani (Mtu-11, Slo-3, 15 & 4), Krishnakatukalu (Mtu-5), Kusumalu (Mtu-16, 19, 22, HR-38), Molagolakulu (Bcp-1, 2, 6), Mypali (Akp-4, 5, 6), Palagummavari (Slo-5), Ramasagaralu (Akp-12), Ratnachudi (Slo-10), Sankisannalu (Akp-2), Sannavadiu (Bcp-5), Sukhadas (HR-47), Tellaru (Slo-19), Vankisannalu (Mtu-8), Amritsari (HR-19), Dalwannam (Mtu-15).
ASSAM	Badshahbhog (S-155), Badal, Basmati (As-3), Boro (I, II, IV & V), Dhabbadal (Ar-108), Dumai (D-204/1), Handique Sali (Sc-117/36), Hati Sali (Sc-36), Kasalath (As-2), Kersail, Koimurali (M-142), Lati Sali (S-22), Laudumra (S-126), Prasad Bhog (S-61), Rangadoria (As-86), Sailbadal (Ar-1), Swarna Sali (Sc-412/56), New Swarna Sali (Sc-412/125).
BIHAR	Badshahbhog (BR-10), Baibrani, Bhadia, Dalia (BR-6), Deoghar, Dolangi (BR-34), Dudhraj, Dudhkani Jessaria (BR-46), Jhulansar (BR-4), Joshwa, Kalmandan, Kalamkatti, Kessore (BR-7 & 8), Kolaba, Mota Chaudana, Motisal (BR-5), Ramsali, Satraj, Sathika, Sona, Tulsi Manjari (BR-9).
GUJARAT	Jirasal (J-280), Kada (Kada-176/12), Kamod (K-118), Kolamba (K-42), Kolipi (EK-70), Pankhali (P-203), Sariu (Sariu-15/14), Sathi (Sathi-34/36), Sukhvel (Sk-20), Sutarsal (Est-39), Zinya (Z-31).
JAMMU & KASHMIR	Basmati (Basmati-370), Shenei (Shenei-257/21), China Rice (972, 1007, 1039).
KERALA	Aryan (Pt-1), Auvakari (Pt-32), Champa (Ur-19), Chenkazhama (Pt-26), Cheriya Aryan (Pt-23), Chethiviruppu (Mo-1), Karutha Chitteni (Pt-12), Vadakkan Chitteni (Pt-20), Elapapoochamban (Pt-31), Kalladasamba (Mo-2), Kodiyan (Pt-27), Marathondi (Wnd-2), Ponnarayan (Pt-2), Thavalakanan (Pt-9), Thekkann Cheera (Pt-10), Velari (Pt-4), Velutharikayama (Pt-5).
MADHYA PRADESH	Ajan (R-7), Badshahbhog (R-14), Banspatri (R-12), Benisar (R-8A), Bhagnmuchi, Bhondu x Parewa (Cross-116), Budhiabko or Hunsa (Cross-4), Chhatri (R-10), Chinoor (R-15), Dilbuxla, Dubraj (R-11), Caorani, Gurmatia (Cross-18), Jhini, Kalikamod, Kalimoonch (Kalimoonch-64), Kurhimohar, Lanji, Luchai (R-8), Ludko, Mota, Motichur, Nagkesar (Cross-51), Nungi (R-2), Nusahi (Asahi x R-2, 16-19), Pandhri Luchai (Pandhri Luchai-16), Safri (Safri-17), Samundarsok, Sultugurmata (R-3), Surmatia (R-4).
MADRAS	Anaikomban (Asd-6), Arupatham Kodai (Co-29), Ayansamba (Co-11), Chinnasamba (Co-5), Chitrakali (Adt-12), Karasamba Red (Asd-1), Karthigasamba (Asd-5), Kavunginpoothala (Pt-15), Konakuruuvai (Adt-16), Konamani (GEB-24 or Kichilisamba), Korangusamba (Adt-10), Kothamalisamba (Adt-2), Kuruvai (Adt-3), Kuruvai Kalyan (Asd-4), Kuruvai Sirumani (Adt-20), Manakkattai (Tkm-5), Muthusamba (Adt-17), Nelloresamba (Adt-5), Ottukichili (Asd-11), Poombalai (Co-2), Poonasamba (Adt-24), Rangoonsamba (Co-23), Red Sirumani (Adt-1), Rubbersamba (Co-25), Sadaisamba (Co-7), Sannasamba (Adt-13), Sendhinayagam (Co-12), Sirumani (Co-19), Swarnakichili (Tkm-6), Vadansamba (Adt-22), Vellaikar (Co-18).
MAHARASHTRA	Ambemohar (Ambemohar-102, 157, 159), Antarsal, Banspatri (Banspatri-R/12), Basmati (Basmati-370), Bhadas (Bhadas-79 & 1303), Bhura Rata (Bhura Rata-4/10), Chimansal (Chimansal-39), Chinoor (Chinoor-R/13), Dodgya (Dodak-35), Garvel (Garvel 1/8), Jirbuti, Jiresal, Kada (Kada-68/1), Kala Rata (Kala Rata-1/24), Kamod (Kamod-253), Kolam, Kolamba (Kolamba-42 & 540), Kolipi (Early Kolipi-70, Late Kolipi-248), Lalsal, Luchai (Luchai-R/8), Krishnasal, Mahadi (Mahadi-4/4), Mainasal, Pandharsi, Panvel (Panvel-61), Patni (Patni-6), EB-17, Sultugurmata, Waksal (Waksal-207), Varangal (Varangal-9, 487 & 1078), Yalkirisal, Zinya (Zinya-14 & 63).
MYSORE	Alur Sanna (S-199), Bangara Kaddi (S-705), Bangara Theega (H-497), Belikannan Hegge (B-281), Chitenni (Pt-20), Coimbatore Sanna (S-661, 699 & 701), Dodgya (Dodgya-622), Halga (Halga-244 & 1690), Halliga (Pt-11), Halubbulu (S-317), Jaddu (Jaddu-1061), Kagisali (Kagisali-44/1), Maharajabhogam (S-924), Maskaty (Maskaty-1315, Pt-14), Mugad (Mugad-81, 141, 161 & 249), Musali (B-194), Mysore Kaddi (S-139), Nagpur Sanna (S-246), Parambu Vattan (Pt-7), Puttabhatta (B-1370 & 1399), Ratnachoodi (S-718 & 749), Red Kayama (Mgl-2), Thavalakkannan (Pt-9), Thogarina (B-16), Velari (Pt-4), Vellaisamba (Co-3), Waner (Waner-1), Yalkirisal (Yalkirisal-4).
ORISSA	Benibhog (B-76), Boblihuta, Badshahbhog (T-412), Bayyahunda (Bam-3), Bhetnasia (FR-43/B), Bordonko, Banko, Basmati (T-608), Chittikona, Chudi (J-5), Duddamani, Dhalaputtia (FR-13/A), Kala Kakkudia, Karandi, Kalakartika (T-442), Kalambank (SR-26B), Machakanta (T-90, Obs-7), Magura (T-1242), Mohl Kunchi, Mypali (Bam-9), Nayapursannam, Padmakesari, Punai, Rangolata, Ratnachudi (Bam-6), Ratanmali, Safi, Soruchinnamali (T-14), Sorumundabali (J-4), Ussa (T-1145), Yerra Kodangi.
PUNJAB	Bara, Bangoa, Basmati (Basmati-370 & 217), Begmi, Chahora, China rice (Ch-988), Dundar (Dundar-43), Hacchu, Hansraj, Jaldhar, Japani Rice (Asahi, Norin, etc.), Jatu, Jhini, Jhona (Jhona-20 & 349), Jhona Keswarwala (Jhona Keswarwala-277), Kali Basmati, Katheri, Lal Basmati, Lal Dhan (R-575), Lal Nakanda (Lal Nakanda-41), Magoi, Mahlar, Munjnoo, Mushkan, Nakandi, Palman-Suffaid (Palman-Suffaid-246), Parmal, Phulpattas (Phulpattas-72), Ramjawain (Ramjawain-100), Ratwa, Rohari, Sathi, Sathra (Sathra-278), Sone, Suffaid Nakhanda, Ziri.

Contd

TABLE 3—*Contd.*

UTTAR PRADESH

Anjana, Anji (T-26), Baljati, Banki Bansi (T-22A), Bansphool (T-139), Basmati (T-3 & N-10 B), Benslot (T-100), Bhadian, Chakia, Chawl (T-21), Dhan, Dhani, Didai, Dunipet (T-9), Garer (Sudha), Hansraj (N-10 B), Jabda, Jarhan (T-36), Jean Jong (Ch-4), Jhona, Kashi, Kalasukhdas (T-23), Pahari, Raimunia, Rajbhog (N-22), Rambhog, Ramjiwain (T-1), Safeda (N-12), Sathi, Sondhi (T-43), Twandwa white (Ch-10), T-136 (T-1 × T-100).

WEST BENGAL.

Achra (Chinsurah-21), Ajan (Bankura-21), Ashkata (Bankura-6), Badkalamkati (Bankura-1, 5 & 13), Badshahbhog (Chinsurah-17), Balan, Banktuli, Bansphul, Basmati (Bankura-33), Bhasmanik (Chinsurah-3), Bhutmuri (Bankura-4), Boldar (Bankura-15), Charnock (Chinsurah-10), Chinisakkhar, Churnakati (Bankura-37), Dadkhani, Dahijira (Bankura-17), Dhaial (Chinsurah-6), Dudhsar (Chinsurah-23), Harkum (Bankura-11), Indrasail (Chinsurah-29), Jhanji (Bankura-2), Jhingasail (Chinsurah-27), Joshwa, Kalandubraj (Bankura-19), Kalamkatti (Chinsurah-37), Kalikalma (Bankura-23), Kalma (Chinsurah 11), Katari-bhog (Chinsurah-39), Kazla, Kele (Chinsurah-2), Kumaragore (Chinsurah-19), Latisali (Chinsurah-25), Maltu (Bankura 9), Manikkalma (Bankura-27), Marichbutti (Chinsurah-8), Nagra (Chinsurah-5), Niger-sail (Chinsurah-35), Nonaramsail (Bankura-25), Patnai (Chinsurah-7, 9), Raghusail (Bankura-31), Rangdhunipagal (Bankura-35), Rupsail (Chinsurah-13), Satika (Chinsurah-12), Sitasail (Chinsurah-15), Sindhurmukhi (Bankura-29), Tilakkachari (Chinsurah-31).

* Based on Ghose *et al.*, appx IV; Ramiah & Rao, appx I; Rep. Marketing Rice, 1954, 43-55, appx XIV XXV; Rice in Orissa, Dep. Agric. Orissa, 1956, 17, 88-93; Recommended Varieties of Paddy for West Bengal, Tech. Bull., No. 2, 1962, Directorate of Agriculture, West Bengal; Information from Rice Specialists of Assam, Bihar, Gujarat, Kerala, Jammu & Kashmir, Madhya Pradesh, Madras, Maharashtra, Mysore, Orissa, Punjab and Uttar Pradesh.

The differences in size and shape of grain which are usually associated with market quality of the processed rice are all controlled by genes varying from one to four. The 'abdominal white' character of the endosperm is said to be dominant over hard. Glutinous endosperm is a simple recessive to non-glutinous character. The scented character of the grain which is highly prized in certain areas is reported to be dominant to no scent, with different segregating ratios being reported by different workers. Colour in the rice grain is confined to the pericarp, the endosperm being always white. Eleven colours varying from white through various shades of red to purple or almost black have been recognized and the factorial constitution of the several colours has been worked out (Ramiah & Rao, 169-70; Ghose *et al.*, 128).

Varietal differences have been noted and anatomical studies of flood resistant types have been reported. To bring the character of flood resistance into the orbit of genic analysis is felt to be a matter of time. Preliminary investigations show that low temperature and anaerobic treatment of seed might prove effective in inducing resistance to submergence (Ramiah & Rao, 196-200).

The capacity to resist drought conditions is thought to be genotypic and governed by specific genes in the varieties concerned. Drought resistance is also said to correspond closely with the percentage of germination in seeds which have been soaked in water for four hours at 15-16° and immediately subjected to 45 to 49° temperature; the greater the percentage of germination the greater the drought

resistance (Ramiah & Rao, 200-03; Rajagopalan, Madras agric. J., 1957, 44, 194).

It is considered probable that resistance to salinity is controlled by specific gene or genes. Experiments are also said to have shown that rice plants can be gradually induced to tolerate salinity by pretreating the seeds and later germinating them in common salt solution of low concentration. The seeds from the most successful plants are subjected to solutions of higher concentration, and the process is repeated. In this way in four years time, seeds could be made to germinate well in 0.45% salt solution (Ramiah & Rao, 203-05).

The capacity possessed by most of the short maturation rices to sprout immediately they are mature is a great disadvantage. From Madras, it has been reported that in the inheritance of dormancy more than one gene is involved and, besides the main genes, certain modifiers are also present. This study has led to breeding of types with short maturation period and grain resistant to sprouting (Shanmugasundaram, Madras agric. J., 1953, 40, 1; Ghose *et al.*, 147).

The inheritance of resistance to blast caused by *Piricularia oryzae* has been studied and the nature of inheritance was found to be different in the several crosses studied. The action of both single and multiple genes has been demonstrated, including a case where resistance is controlled by two complementary genes. Investigations in U.S.A. have revealed operation of several recessive genes for resistance against *Helminthosporium*; workers in India have indicated existence of some physiological races in

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Helminthosporium (Ramiah & Rao, 215-24; Nagai, 365-72).

Breeding—Rice breeding is being carried out in nearly 75 research stations distributed in various States in India and also at the Central Rice Research Institute, Cuttack, India. So far 445 improved types have been evolved, 394 by pure line selections in natural populations, and 51 from crosses specially undertaken. The most widely grown varieties in large concentrated areas have received attention, but there are still areas where natural variability in the types under cultivation remains to be exploited. Many of the improved types are now included in the FAO Catalogue of Rice Genetic Stocks. No new type is

recommended to farmers unless it gives a minimum of 10% improvement in yield over the local variety which it is intended to replace. Table 4 gives a list of improved types grown or recommended for growing in the rice growing regions in different States in India (Ghose & Butany, *Proc. Indian Acad. Sci.*, 1959, 49B, 287).

Among the available improved types only some are grown on extensive areas. Some of the most outstanding of the existing improved types are: *Mtu-1*, *Mtu-15* and *HR-19* of Andhra Pradesh; *Chinsurah-7* of West Bengal; *Kolamiba* strains of Maharashtra; *Cross-4* and *Cross-18* of Madhya Pradesh; *GEB-24*, *Co-2*, *Co-25*, *Tkm-6* and *Asd-1* of Madras; *T-141* and

TABLE 4—CHARACTERISTICS OF THE CHIEF RICE GROWING REGIONS AND IMPROVED TYPES RECOMMENDED FOR CULTIVATION

State, Latitude, Normal annual rainfall and Characteristics of soil*	Rice growing regions†	Improved types grown or recommended
Andhra Pradesh 13° to 20°N Southwestern region—613 mm. Hyderabad region—760 mm. Coastal region—1,020 mm.	Eastern districts of Nellore, Chittoor, Anantapur & Cuddapah	Adt-3 & 22; Bcp-1 to 5; GEB-24; Mtu-9 & 15; Co-20
Alluvial soils in the deltaic areas of Godavari, Krishna & Pennar rivers; red soils & laterite soils mainly in the western areas & in some northern districts; black soils in some western districts; & coastal sands & sandy loam	Vishakhapatnam, Godavari, Krishna, Guntur & part of Kurnool dist.	Akp-1 to 5, 8 & 11; Adt-3; Bam-1, 3 & 6; GEB-24; Mtu-1, 3, 5 to 19 & 22; no. 3778
Assam 22° to 29°N 2,475 mm.	Hyderabad region	IIR-1, 5, 8, 9, 12, 19, 21, 22, 33, 35, 38, 39, 47, 59 & 67; Rdr-2, 4, 7, 19, 22 & 47
Alluvial soils in the Brahmaputra & Surma valleys; laterite soils in the mountainous north eastern regions & heavy loams in the valleys in Khasi hills area	Godavari delta (Areas subject to flooding)	Slo-1 to 19; Eultures-272, 279, 285 & 289; Pla-1 to 4; Ar-108/1
Bihar 22° to 27°N Northern region—1,225 mm. Chota Nagpur region—1,300 mm.	Saline areas	SR-26B; Mtu-9; C-72 & 87; no. 1327
Alluvial soils: clay loams to sandy loams to the north and heavier clay soils to the south of the Ganges; red & brown soils in Chota Nagpur, Bhagalpur & Monghyr tracts	Alluvial plains	As-2, As-3 & As-86; M-142; As-C-536/143; S-22, S-61, S-126 & S-155; Sc-36, Sc-406/93, Sc-412/56, Sc-117/36 & Sc-412/125
Gujarat 20° to 24°N 830 mm.	Areas submerged under 60-180 cm. of water	Ar-1 & Ar-108
Alluvial soils varying from sandy loam to clay loam in northern & southern areas	Areas submerged under 360-450 cm. of water	EB-1 & EB-3
	Areas with irrigation facilities	Boro-I, Boro-II, Boro-IV & Boro-V
	High altitudes	Khonorullo
	Throughout the State	BR-48, BR-24 (Chinese types) & BR-7
	Lowlands	BR-8, BR-9 & BR-10
	Uplands	BR-34 & BR-6
	Canal irrigated tracts	BR-5
	Chota Nagpur tract	BR-4
	North Bihar liable to seasonal flooding	BR-13, BR-49 & BR-46
	Southern areas of the State comprising Surat & Baroda dist. & northern areas comprising Panch Mahal, Kaira & Ahmedabad dist.	Sathi-34/36; Sariu-15/14; Kada-176/12; EX-70; Sk-20; Est-39; Z-31; K-42 & K-118; J-280; P-203

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TABLE 4—*Contd.*

State, Latitude, Normal annual rainfall and Characteristics of soil*	Rice growing regions†	Improved types grown or recommended
Jammu & Kashmir 32° to 37°N 1,050 mm. Alluvial soils, sandy loam to loam, acidic to alkaline (<i>pH</i> , 5.8–8.5) with rich organic matter	Up to alt. of c. 450 m. Jammu Srinagar, Anantnag & Baramula, Kashmir Alt. of 1,700–2,000 m. in the various hilly areas of Kashmir	Basmati-370 Ch-972, 1007 & 1039 ; K-60 Ch-971 ; Shenei-257/21
Kerala 8° to 13°N 2,635 mm. Alluvial soils ranging from sandy to rich peaty along river banks & coastal areas ; red & lateritic soils in Malabar & southern areas	Northern region comprising Cannanore, Calicut & Palghat dist. Central region comprising Trichur, Ernakulam & Kottayam dist. Southern region comprising Quilon, Alleppey & Trivandrum dist.	Ptb-1, 2, 4, 5, 9, 10, 12, 20, 26 & 31 ; Co-25 ; Wndl-2 Ptb-1, 2, 4, 9, 10, 12, 20, 22, 23, 27 & 32 Ptb-4, 10, 23 & 27 ; Ur-19 ; Mo-1 & 2
Madhya Pradesh 18° to 27°N Eastern & south eastern regions—1,420 mm. Light sandy, red & yellow loams & clays in the Mahanadi basin in the eastern part of the State & rich black soils in the Wainganga, Bag & Deo river basins	Upland & rain fed areas of the State Irrigated areas Areas infested with wild rice	N-22 ; Laloo-14 ; Safeddhhan-3 ; R-2 & 3 ; Hybrid-1 R-4, 7, 8, 8/A, 10, 11, 12, 14 & 15 ; Pandhi-64 ; Luchai-16 ; Kalimoonch-64 ; Cross-4, 18 & B/2 Purple leaved hybrids-1, 19, 51, 34, 5/18, B-11/2 & 116
Madras 8.0° to 13.5°N 891 mm. Alluvial soils along the banks of the Cauvery & deltaic areas in Thanjavur dist. ; red, black & mixed types of soil in the central & southern areas ; red soils & sandy loams in the eastern coastal areas	Southern region of the State comprising Madurai, Ramanathapuram, Tirunelveli & Kanniyakumari dist. Eastern region comprising Thanjavur, Tiruchirappalli, Chingleput, N. Arcot & parts of S. Arcot dist. Central region comprising Coimbatore & Salem dist. Areas subject to salinity and alkalinity Areas subject to moderate flooding	Asd-1, 4 to 6, 8, 11 & 12 ; GEB-24 ; Co-19, 25, 29 & 30 Adt-1, 3, 8, 10, 20, 22, 24 & 26 ; GEB-24 ; Co-18, 19, 25, 29, 30 & 31 ; Tkm-1 & 6 ; Bep-1 ; Asd-5 ; Bam-3 Asd-11 ; Co-2, 19, 23, 25, 29 & 30 ; GEB-24 SR-26B ; Pvr-1 Ptb-15 ; Culture-2172
Maharashtra 15.5° to 21.5°N Coastal region—2,776 mm. Deccan region—782 mm. Coarse sands to clay loams in Thana & Kolaba dist. ; lateritic soils in Ratnagiri & Kolhapur dist. ; medium black soils in the Deccan plateau ; rich black soils in the Wainganga basin in Bhandara dist.	Coastal region comprising Thana, Kolaba & Ratnagiri Maval region comprising Poona, Satara & Ahmednagar dist. Deccan canal area Wainganga basin in the dist. of Chanda & Bhandara	Zinya-63 & 14 ; Kolamba-540 & 42 ; Kada-68/1 ; Mahadi-4/4 ; Bhadas-1303 & 79 ; Garvel-1/8 ; Patni-6 ; Panvel-61 ; Waksal-207 ; Varangal-487 ; Early Kolipi-70 ; Late Kolipi-248 ; Kala Rata-1/24 ; Bhura Rata-4/10 Ambemohar-102, 157 & 159 ; Chimansal-39 ; Varangal-9 ; Kamod-253 ; Dodak-35 Basmati-370 ; Krishnasal EB-17 ; Sultu Gurmatia ; R-8-Luchai ; Chinnoor-R/15 ; Banspatri-R/12
Mysore 11.5° to 18.5°N Coastal region—2,776 mm. Southern region—914 mm. Heavy black soils in the northern areas ; red soils in the eastern dist. & laterite soils elsewhere & alluvial soils along the coast	Southern region comprising Mysore, Mandya, Hassan & Coorg dist. Tungabhadra area Malnad areas of former Mysore State Malnad areas of former Bombay Karnatak	S-139, 199, 246, 317, 497, 661, 699, 701, 705, 718, 749, 924 & 1092 DP-17 & 33 B-16, 194, 281, 1370 & 1399 Antarsal-67, 90 & 200 ; Dodgya-622 ; Mugad-81, 141, 161 & 249 ; Waner-1 ; Yalkirisal-4 ; Kagisali-44/1 Halga-244 & 1690 ; Jaddu-1061 ; Maskaty-1315 Ptb-4, 7, 10, 11, 14, 16, 17 & 20 ; Co-3 & 14 ; Mgl-1 & 2

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TABLE 4--*Contd*

State, Latitude, Normal annual rainfall and Characteristics of soil*	Rice growing regions†	Improved types grown or recommended
Orissa 18° to 22.5°N 1,445 mm.	Coastal region comprising Cuttack, Puri, Balasore & Ganjam dist.	B-76 ; N-136 ; PtB-10 ; Ch-55 & 62 ; Ac-2150 ; T-90, 442, 1145, 141 & 1242 ; BBS-873 ; Bam-11 ; FH-42/12 & 60/124
Alluvial soils with 30-50% clay in the coastal river basins; laterite & red soils in the eastern ghat area & saline soils near the sea coast	Hilly tracts in the region of the eastern ghats comprising Koraput, Sambalpur & Kalahandi dist.	J-4, 5 & 10 ; FH-158 ; SP-1 ; Bam-3, 6 & 9
Punjab 28° to 32°N 590 mm.	Dalua areas under Hirakud irrigation system	Ch-55 ; PtB-10 ; Mtu-9 & 15 ; Hr-19
Alluvial sandy & clay loams in the plains	Saline areas	SR-26B
Uttar Pradesh 24° to 31°N Eastern region—993 mm. Western region—933 mm.	Flooded areas	FR-13A & FR-43B
Alluvial sandy & clay loams & clays in the western, central & eastern regions; clay loams in parts of the terai area & sandy loams in others; shallow brown soils, podsols & meadow soils in the mountainous regions	Plains	Jhona-20 & 349 ; Jhona kesarwala-277 ; Basmati-370 & 217 ; Palman Suffaid-246
	Kangra hills	Ramjawain-100 ; Phulpattas-72 ; Lal Nakanda-41 ; China-988 ; T-23 ; R-575
	High hills (Kulu Valley)	Dundar-43 ; Ch-988
	Central region	N-22 & 12 ; T-9, 21, 23, 26, 100 & 136 ; Ch-4 & 10
	Mid-eastern region	Sudha ; N-22 & 12 ; T-9, 21, 23, 36, 100 & 139 ; Ch-4 & 10
	North eastern region	Sudha ; N-22 ; T-9, 21, 22A, 100 & 136 ; Ch-10
	Eastern region	Kashi ; N-22 ; T-9, 21, 26, 36 & 139
	Bundelkhand region	Kashi ; N-22 ; T-9, 23, 36 & 100 ; Ch-10 & 4
	Vindhyan region	Sudha ; Kashi ; N-22 ; T-9, 21, 26, 36 & 139
	Hilly region	N-22, 10B & 12 ; Ch-4 & 10 ; T-3 & 21
	Terai region	N-22 & 10B ; Sudha ; T-3, 9, 21, 22A, 43 & 100 ; Ch-10
	Western region	N-22 ; T-1, 3, 9, 21 & 100 ; Ch-10
	Mid-western region	N-22 ; Sudha ; T-9, 21, 43, 100 & 136 ; Ch-10
	South western region	N-22 & 10B ; T-9, 21, 23, 26 & 100 ; Ch-4 & 10
West Bengal 22.5° to 27°N 1,909 mm.	Plains	Chinsurah-2 to 8, 10 to 18, 23, 25, 27, 29, 35, 37, 47, 49 & 51 ; Bankura-1, 6 & 37
Laterite & red soils in western dist. ; alluvial soils in deltaic areas ; coastal soils of tidal origin & terai soils at the foothills of Himalayas	Lateritic tracts	Bankura-2, 4, 5, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 29, 31, 33 & 35
	Low lying areas subject to flooding	Chinsurah-19, 21 & 31
	Saline areas	FR-13A & FR-43B ; Chinsurah-19 ; SR-26B
	Hills	MPRS-1 to 3

* Ghose *et al.*, 21-34, appx I, 414-17.

† Information from Rice Specialists of Assam, Bihar, Gujarat, Jammu & Kashmir, Kerala, Madhya Pradesh, Madras and Maharashtra ; Director of Agriculture, Mysore ; Economic Botanists of Orissa, Punjab and Uttar Pradesh.

SR-26B of Orissa; *Basmati-370* of Punjab; and *T-136* of Uttar Pradesh. *GEB-24* of Madras is the most cosmopolitan type and is being grown in large areas outside Madras, as well as in countries outside India, amongst which West Africa and East Pakistan may be mentioned (Ghose *et al.*, 194-101).

Varieties of rice in India can be broadly divided into 4 maturity groups: (1) very early—110 days and less; (2) early—110 to 140 days; (3) late—150 to 170 days; and (4) very late—above 180 days. Groups 2 and 3 are the most important, while group 4 is less important since it is confined to flooded areas. Early maturing rices are of special importance to India because of uncertain or limited supplies of water. They are also required for areas with multiple cropping. Early maturing rices are generally insensitive to photoperiod and are, therefore, adapted to a wider range of sowings. Breeding for earliness has therefore been an important item on the programmes of many experiment stations and about 170 or nearly 40% of the improved types belong to the maturity groups 1 and 2. Early maturing rices introduced from China have been tried in many States, and some of them have been found suitable under upland conditions. The area under these rices is rapidly expanding, and in Kashmir the Chinese rices have almost completely replaced the local ones [Ghose & Butany, loc. cit.; Richharia & Misro, *Rice News Teller*, 1961, 9(1), 17].

There are rice areas in Assam, West Bengal, Orissa, Andhra Pradesh, Madras and Kerala subject to intermittent floods, the depth of water rising to about a metre. Types *Ar-1*, *EB-1* and *EB-3* of Assam, *Ar-108/1* and *Pla-1 to 4* of Andhra Pradesh, *Ptb-15* and *culture-2172* of Madras, *FR-13A* and *FR-43B* of Orissa, and *Chinsurah-19*, *21* and *31* of West Bengal have been found suitable for deep water conditions [Richharia & Misro, *Indian Agriculturist*, 1960, 5, 135; Richharia, *Span*, 1961, 4(1), suppl., 1-39; Venkatanadhachari, *Andhra agric. J.*, 1959, 6, 174].

Rice areas close to the sea are subject to saline water inundation. Some types obtained by selection such as *SR-26B* of Orissa, *Kala Rata-1/24* and *Bhura Rata-4/10* of Maharashtra, and *Chinsurah-13* and *Chinsurah-19* of West Bengal are tolerant to saline conditions, and are grown extensively in these States. Type *SR-26B*, because of its early maturity and good quality rice, has spread to several States outside Orissa [Shendge *et al.*, *Rice News Teller*, 1959, 7(2-3), 18; Abdul Samad *et al.*, *ibid.*, 1960, 8(2), 10].

Among the existing improved types, the following

have proved somewhat drought resistant: *Akp-1*, *Akp-2*, *Bcp-2* and *Bcp-5* in Andhra Pradesh; *Tkm-1*, *Asd-4*, *Asd-8* and *Bam-3* of Madras; *Bam-3* of Orissa; *N-22* of Uttar Pradesh; and *Chinsurah-25* and *Chinsurah-27* of West Bengal.

Almost all varieties grown in India have weak straw and lodge badly even with a slight improvement in soil fertility. Types have been obtained by breeding which have straw somewhat resistant to lodging, but even these cannot stand intensive manuring. Types typically resistant to lodging are poor in tillering and yield. Some of them also have a maturation period too long to suit local conditions. A large programme of hybridization to evolve strains resistant to lodging has been undertaken at Coimbatore and Cuttack (Ramiah & Rao, 187-91).

All Indian varieties shatter grain to some extent. It has been estimated that loss in yield due to shattering may vary from 5 to 30%. Shattering is also influenced by environment, chiefly climate. Varieties that do not shatter when grown in the plains are found to shatter badly when grown in the Kashmir valley at an altitude of 1,500 m. *Bulus* of Java and many of the Japonica rices exhibit little shattering. In fact, in the Indica \times Japonica hybridization project in progress in India, breeders in Andhra Pradesh and Orissa have obtained progenies with the non-shattering character of Japonica. Among the improved types in India, the following are non-shattering: *S-22* of Assam; *Mtu-7* of Andhra Pradesh; *Cross-B/2* of Madhya Pradesh; *Ptb-9* of Kerala; and *GEB-24* and *Co-25* of Madras.

Breeding for blast (*Piricularia oryzae*) resistance has been an important programme of Madras State and new progenies completely resistant to blast have come out of this work: *Co-25*, *Co-29* and *Co-30* are such outstanding productions. Breeding for blast resistance has been intensified in several centres in Bombay and Andhra Pradesh and also at the Central Rice Research Institute at Cuttack. All the types are systematically tested for resistance, and special techniques have been developed to assess the degree of susceptibility in individual plants. Besides those evolved in Madras, there are now available an additional 30 types which are resistant to blast. Of these, one is an introduction from China and three from Thailand. *Mugad-249* is an important resistant strain of Malnad area in northern Mysore [Padmanabhan *et al.*, *Rice News Teller*, 1960, 8(2), 19].

Special mention may be made of breeding rice types showing greater response to heavy manuring.

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It is one of the main objectives of the FAO Co-operative Hybridization Project between Indica and Japonica rices started in 1951. Japonica rices as a group give a higher response, while in Indica rices, those with a high response to fertilizers are rare. The position in India now compares to what existed in Japan fifty years ago. In Japan the selection has always been made under conditions of heavy fertilizing, so that there has been a continuous selection in favour of high response types. In the Indica area, however, selection has been made with little or no manuring and, therefore, tended towards development of types with no response. The main objective of the co-operative Indica \times Japonica hybridization project is to incorporate the valuable characteristics of the Japonica rice into Indica rice, and develop new cultures combining the high yield and response to heavy manuring of Japonica with the hardiness and adaptability to tropical conditions of the Indica. Other characters besides response to manuring which can come from the Japonica parent in the progenies are, non-lodging straw and non-shattering grain. The actual crossing work between selected Indica and Japonica rices was undertaken at the Central Rice Research Institute, Cuttack, and the F_2 seed sent to the different States from 1952 onwards. Besides the direct F_2 seed, some seed of the back cross of the F_1 to the Indica parent had also been sent. The work is generally in F_1 - F_2 stage in all States, except Andhra Pradesh, where by growing the crop twice in the year the material has reached the F_{14} stage. The selected material has reached the yield trial stage in Andhra Pradesh, Orissa, Maharashtra, Madras, Mysore and West Bengal; and the present position is that a few progenies maturing comparatively earlier than the Indica parent and with strong straw, good grain and higher yield than the Indica have been obtained, thus emphasizing the great possibilities that exist in the programme. Response of some of these hybrids to heavy nitrogenous manuring has also been reported (Chami & Mariakulandai, *Madras agric. J.*, 1962, **49**, 325).

The F_1 and F_2 populations exhibit a very high percentage of spikelet sterility, the percentage varying from 10 to 90 in the different crosses. This sterility has, however, not proved an obstacle, as by repeated selection fully fertile progenies have been obtained. From the material available from the Indica \times Japonica project it has been found that most of the promising cultures have come out of the back cross [Indica \times (Indica \times Japonica)] indicating that this should receive

attention in the future programme [Pawar *et al.*, *Rice News Teller*, 1959, **7**(2-3), 6; Sampath, *ibid.*, **7**(2-3), 16; Richharia & Misro, *J. biol. Sci.*, 1959, **2**(2), 35].

Breeding for higher nutrient quality is feasible and becomes extremely important in Asiatic countries where rice forms the chief food. It has been recently shown that variations exist in protein content from 9.4 to 11.3% in types with long glumes and there is a possibility of obtaining cultures with higher protein content. Studies have also shown that among nearly 90 types analyzed for their thiamine content, the variation was from 1.0 to 6.0 $\mu\text{g./g.}$ and environmental conditions like soil and manuring did not alter much the thiamine content, which is an inherent character of the type. Nearly 25% of the types had 4.0 $\mu\text{g./g.}$ and more of thiamine. Since the types analyzed were all of improved types recommended by the Departments of Agriculture, it is clear that high yield can be combined with higher thiamine content in a breeding programme (Sampath & Seshu, *Curr. Sci.*, 1957, **26**, 139).

As the Japonica group of rices are adapted to long day length and low temperature conditions, they do not do well under the tropical conditions of India, where higher temperatures and shorter day lengths prevail during the major period of the main rice growing season. However, satisfactory performance is reported from certain areas like Kashmir and higher elevations of Punjab, where temperature is congenitally low and the days are relatively longer during rice growing season. In these areas some types introduced from China and Taiwan are said to have done very well. Trials conducted in the Central Rice Research Institute, Cuttack, are said to show that after continuous cultivation of Japonica rices over the last 10 years or more a number of them (36 out of 69) have completely adapted themselves to the local climatic conditions and have given better response than the two Indica rices grown along with them for comparison; 20 of them have given almost one and a half times the yield of the Indica controls [Richharia & Misro, *Rice News Teller*, 1961, **9**(1), 17].

RICE GROWING IN INDIA

Area & Production—Rice is the most extensively cultivated cereal crop in the world after wheat. Its cultivation is particularly concentrated in Asian countries which together include about 90% of the world area. The two most important rice producing countries are India and China which account for

about 28 and 26% respectively of the total world area. The other important rice producing countries are: Pakistan, Indonesia, Thailand, Burma, Japan and Philippines in Asia, Brazil and U.S.A. in America and Malagasy (Madagascar) and Egypt in Africa. Small quantities are also grown in a few southern European countries like Italy and Spain (Table 5).

In India the rice crop occupies the largest area among all crops and accounts for as much as 21% of the total cropped area. On an average, the area under rice is said to form about 36% of the total area under cereals and 28% of the total area under food grains inclusive of pulses. With regard to production, rice is said to account roughly for 48% of the total under foodgrains (Rice Economy of India, 3).

Rice cultivation in India is mainly concentrated in the river valleys, deltas and low-lying coastal areas

of north eastern and southern India, in the States of Bihar, West Bengal, Uttar Pradesh, Madhya Pradesh, Orissa, Andhra Pradesh, Madras, Assam, Maharashtra, Mysore and Kerala, which together contribute more than 95% of the area and production in the country. Table 6 summarizes the area and production of rice in different States in India during the period 1957-58 to 1962-63.

The average area under rice in India in the quinquennium ending 1961-62 was 82 million acres (33.2 million ha.) and the corresponding production 30.7 million tons (31.2 million tonnes). There has been a general increase in the area and production of rice in the post-war period and particularly since the inauguration of the First Five Year Plan. The area and production of rice in India during the period 1949-50 to 1962-63 is given in Table 7.

TABLE 5—AREA AND PRODUCTION OF RICE IN IMPORTANT PRODUCING COUNTRIES OF THE WORLD*

	Area (thousand acres)					Production (thousand tons)				
	1957-58	1958-59	1959-60	1960-61	1961-62	1957-58	1958-59	1959-60	1960-61	1961-62
India	79,784	81,437	82,829	82,947	83,669	25,110	30,354	30,963	33,658	33,610
China	80,000	81,000	73,000	77,000	75,000	59,800	78,300	..	..	53,800
Pakistan	22,887	22,487	24,125	24,804	23,964	8,461	7,897	9,461	10,533	10,575
Indonesia	16,791	17,265	17,675	18,011	16,946	7,223	7,551	7,849	8,042	7,825
Thailand	10,790	12,617	13,083	14,029	14,018	3,563	4,597	4,501	4,983	5,275
Burma	9,559	9,907	10,314	10,370	10,052	3,495	4,404	4,696	4,537	4,403
Japan	8,003	8,038	8,126	8,173	8,154	10,392	10,874	11,334	11,659	11,260
Philippines	7,345	7,341	8,239	7,902	7,855	2,017	2,321	2,361	2,335	2,460
Brazil	6,213	6,629	7,328	7,778	8,058	2,450	2,624	3,067	3,399	3,482
S. Vietnam	6,716	5,661	5,930	5,728	5,817	2,010	2,668	3,208	3,121	2,903
N. Vietnam	5,414	5,523	5,618	5,575	5,724	2,487	2,883	3,271	2,653	2,935
Cambodia	3,031	3,761	3,983	3,516	2,200	902	726	894	972	787
Malagasy (Madagascar)	2,150	2,088	2,202	2,174	2,944	796	754	811	783	817
Taiwan	1,935	1,922	1,917	1,893	2,039	1,652	1,702	1,668	1,718	1,805
U.S.A.	1,340	1,415	1,586	1,595	1,590	1,343	1,390	1,689	1,730	1,735
Ceylon	958	1,090	1,127	1,210	1,256	439	509	555	597	630
Egypt	759	538	757	733	557	1,055	667	997	965	742
Italy	311	331	336	328	305	414	479	491	399	455
Soviet Union	279	262	237	..	250	137	141	139	121	156
Spain	166	161	165	162	153	252	244	251	235	255
Other Countries	19,748	20,089	20,060	20,472	20,499	8,839	8,956	9,123	9,081	9,946
TOTAL	284,179	289,562	288,637	294,400	291,050	142,837	170,041	97,339†	101,821†	155,856
	(115,003)	(117,181)	(116,807)	(119,140)	(117,784)	(145,130)	(172,770)	(98,901)	(103,455)	(158,350)

* *Grain Crops*, Commonwealth Econ. Comm., No. 8, 1962, 121-25, Tables 79-80; No. 9, 1963, 134-37, Tables 79-80.

† Does not include figures for China.

Figures in brackets show total area in thousand hectares and total production in thousand tonnes.

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TABLE 6—AREA AND PRODUCTION OF RICE IN DIFFERENT STATES IN INDIA*

State	Area (thousand acres)					Production (thousand tons)				
	1958-59	1959-60	1960-61	1961-62	1962-63	1958-59	1959-60	1960-61	1961-62	1962-63
Bihar	12,933	12,335	12,944	12,580	12,843	4,419	3,826	4,472	4,335	4,213
West Bengal	10,534	10,916	11,379	10,926	10,984	4,057	4,173	5,368	4,722	4,340
Uttar Pradesh	10,206	10,251	10,340	10,313	10,449	2,984	2,426	3,101	3,291	3,071
Madhya Pradesh	9,881	10,106	10,230	10,363	10,341	3,278	3,161	3,402	3,441	2,276
Orissa	9,560	10,570	9,350	10,069	10,970	2,140	3,658	3,670	3,663	3,593
Andhra Pradesh	7,237	7,396	6,854	7,911	7,532	3,656	3,674	3,498	3,941	3,605
Madras	5,712	5,726	5,913	6,271	6,340	3,298	3,406	3,559	3,846	3,800
Assam	4,336	4,208	4,319	4,379	4,449	1,620	1,618	1,640	1,649	1,501
Maharashtra	3,003	3,066	3,085	3,113	3,179	1,269	1,210	1,279	1,379	1,116
Mysore	2,362	2,365	2,366	2,411	2,473	1,293	1,311	1,237	1,314	1,350
Kerala	1,899	1,900	1,924	1,860	1,947	936	1,022	1,063	987	1,088
Gujarat	1,158	1,173	1,251	1,412	1,303	437	376	262	509	372
Punjab	856	970	1,083	1,103	1,163	316	406	424	463	454
Jammu & Kashmir	504	466	559	562	563	221	208	234	235	242
Tripura	403	426	421	432	446	131	153	156	167	171
Manipur	392	392	393	395	400	102	93	124	101	106
Rajasthan	195	247	242	250	280	85	114	64	88	99
Nagaland	141	187	162	165	165	66	86	65	73	73
Himachal Pradesh	111	112	112	113	114	41	38	42	46	35
Andaman & Nicobar Is.	12	15	17	17	17	4	5	6	6	6
TOTAL	81,437 (32,956)	82,829 (33,520)	82,947 (33,567)	84,650 (34,257)	85,961 (34,787)	30,354 (30,841)	30,963 (31,460)	33,658 (34,198)	34,257 (34,807)	31,512 (32,018)

* Rice Economy of India, 117, Table 1; Agric. Situat. India, 1960-61, 15, 792, 1316; 1961-62, 16, 45; 1962-63, 17, 213; 1963-64, 18, 374.

Figures in brackets give total area in thousand hectares and total production in thousand tonnes.

TABLE 7—AREA AND PRODUCTION OF RICE IN INDIA

(1949-50 to 1962-63)

	Area (thousand acres)	Production (thousand tons)
1949-50	75,414 (30,520)	23,170 (23,541)
1950-51	76,135 (30,812)	20,251 (20,575)
1951-52	73,713 (29,832)	20,964 (21,299)
1952-53	74,056 (29,970)	22,537 (22,898)
1953-54	77,318 (31,291)	27,769 (28,213)
1954-55	76,020 (30,765)	24,821 (25,218)
1955-56	77,891 (31,522)	27,122 (27,556)
1956-57	79,320 (32,101)	28,282 (28,735)
1957-58	79,447 (32,152)	24,885 (25,283)
1958-59	81,437 (32,956)	30,354 (30,841)
1959-60	82,829 (33,520)	30,963 (31,460)
1960-61	82,947 (33,567)	33,658 (34,198)
1961-62	84,650 (34,257)	34,257 (34,807)
1962-63	85,961 (34,787)	31,512 (32,018)

Figures in brackets give area in thousand hectares and production in thousand tonnes.

The important rice growing districts in each State, which together account for nearly half the area under this crop, are as follows: Gaya, Santal Parganas, Shahabad, Purnea and Ranchi in Bihar ; Midnapore, 24-Parganas, Burdwan and Bankura in West Bengal ; Basti, Gonda, Gorakhpur, Azamgarh, Bahraich and Deoria in Uttar Pradesh ; Raipur, Bilaspur, Durg and Raigarh in Madhya Pradesh ; Cuttack, Sambalpur, Puri and Balasore in Orissa ; W. Godavari, E. Godavari, Krishna, Guntur, Srikakulam and Nellore in Andhra Pradesh ; Thanjavur, Chingleput, S. Arcot, N. Arcot and Tiruchchirappalli in Madras ; Kamrup, Goalpara, Sibsagar and Darrang in Assam ; Bhandara, Chanda, Thana, Kolaba and Ratnagiri in Maharashtra ; S. Kanara, Shimoga, Dharwar and N. Kanara in Mysore ; Palghat, Calicut, Trichur and Cannanore in Kerala ; Surat, Panch Mahals, Baroda and Kaira in Gujarat ; and Karnal, Kangra, Gurdaspur, Amritsar and Ferozepur in Punjab.

Climate & Seasons—Rice is grown in both tropical and sub-tropical zones, from about 45°N to 40°S latitude. It requires high temperature and high humidity with abundance of water during its growth. Therefore, rainfall and its distribution, temperature and day length have a marked influence on growth and yield of rice, and determine where and to what extent the crop can be grown. Rice cultivation in India extends from 8° to 35°N latitude. There are rices grown at sea level in the river deltas, in areas even below sea level with protective embankments as in Kerala, in 3–5 m. of water as in Assam and West Bengal, and at altitudes of 1,000–1,500 m. and even more in Kashmir and on the slopes of the Himalayas (Ghose *et al.*, 15 ; Grist, 8).

As the bulk of the crop in India is entirely dependent on rainfall, variations in the arrival, duration, distribution and intensity of the South-West monsoon (July–October) have a large influence on rice cropping. Only a third of the area under rice has irrigation facilities to supplement rainfall and Table 8 summarizes the available data regarding irrigated areas in different States. Rice cultivation follows more or less the South-West monsoon rainfall line. In

Assam, West Bengal, South Bihar and Orissa, where the rainfall is high, rice occupies 80% of the cultivated area. Further south as the rainfall decreases, rice occupies 30 to 40% of the cultivated area and is concentrated mainly in the coastal areas of Andhra Pradesh, Madras, Kerala, Maharashtra and Gujarat States. In central and northern India, rice is grown wherever rainfall conditions are favourable (Ghose *et al.*, 15).

The average temperature during the rice season ranges between 21 and 35° , the temperature being high at planting and during the growth of the crop and falling gradually at the time of harvest. In the eastern region and peninsular India, the temperature range may be shorter and the maximum even slightly higher than 35° , but the more uniform and warmer conditions enable more than one crop being taken in a year, the only limiting factor being availability of water. In northern India, where temperature goes below 15° after October, only one crop can be grown. In India, difference of day length in the rice growing season ranges from 40 minutes to 2 hours ; there are both photosensitive and insensitive types grown, the former having longer maturation period

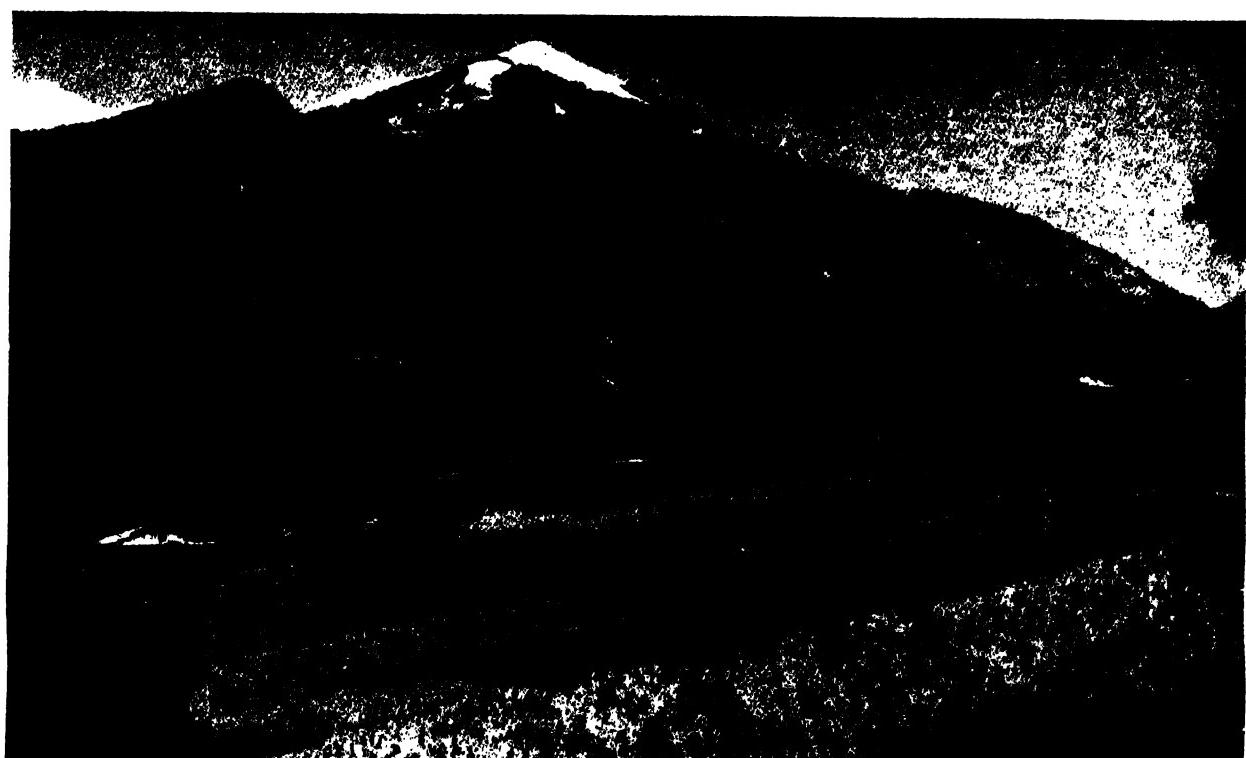


FIG. 52—RICE FIELDS IN KULU VALLEY

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TABLE 8—IRRIGATED AREA UNDER RICE IN DIFFERENT STATES
(in thousand acres)

	1958-59	1959-60	1960-61
Andhra Pradesh	6,967 (93.7)	7,118 (96.2)	6,801 (99.1)
Assam	1,433 (33.6)	1,433 (34.1)	1,433 (33.2)
Bihar	4,184 (32.4)	3,677 (30.0)	4,171 (33.9)
Gujarat*	..	169 (14.5)	164 (13.1)
Jammu & Kashmir	479 (92.0)	493 (100.0)	511 (91.3)
Kerala	874 (46.0)	884 (46.0)	874 (45.9)
Madhya Pradesh	1,063 (10.8)	1,214 (12.0)	1,196 (11.7)
Madras	5,147 (91.5)	5,126 (89.5)	5,696 (96.5)
Maharashtra	751 (17.4)	644 (21.0)	673 (21.5)
Mysore	1,372 (56.7)	1,428 (60.4)	1,522 (64.3)
Orissa	2,425 (26.4)	2,425 (22.9)	2,425 (26.0)
Punjab	660 (7.3)	709 (7.3)	779 (7.2)
Rajasthan	19 (9.6)	29 (11.7)	37 (15.3)
Uttar Pradesh	1,164 (11.4)	1,357 (13.2)	1,240 (12.0)
West Bengal	3,017 (28.6)	3,017 (27.6)	3,017 (26.5)
Himachal Pradesh	52 (46.4)	52 (46.4)	52 (46.4)
Manipur	149 (38.5)	168 (43.0)	168 (43.0)
Tripura	7 (1.8)	15 (3.8)	24 (5.6)
TOTAL	29,765 (36.8)	29,951 (36.1)	30,785 (37.1)

* Figures for Gujarat for 1958-59 are included in those given for Maharashtra for the same year.

Figures in brackets denote the percentage of the irrigated area to the total area under rice.

and grown during July–December and the latter with shorter maturation period, grown in June–September and January–April. While acre yields in countries in higher latitudes are higher than in lower latitudes, within India (8° – 35° N) no relation is indicated between yield and latitude (Ghose *et al.*, 17).

There are three distinct seasons when rice is

harvested, *aus* or autumn rice, *aman* or winter rice and *boro*, spring or summer rice. The most important crop for the whole of India is the *aman* which coincides with South-West monsoon and may be planted any time in June–July and harvested in September–December; the maturation period ranges between 150 and 180 days. The *aus* crop is planted in May–June and harvested in September–October, the maturation period varying from 90 to 120 days, the crop grown under upland conditions being generally shorter in maturation period. The *boro* crop is planted in December–January and harvested in March–April. Over large areas only one crop of a long maturation period of about 5–6 months is grown in the year and the land remains fallow after harvest; where water facilities exist, two or three crops may be grown on the same land, one of a short maturation period and the other of a medium to long maturation period. In parts of S. India, planting season is not definite as the sowing depends upon rainfall and accumulation of water in wells, storage tanks or lakes which are the main sources of irrigation (Table 9) (Ghose *et al.*, 18–19).

Soils.—The chief soil types on which rice is grown in India are alluvial soils, laterite soils, alkaline soils and black soils; with irrigation facilities it is also grown on red soils. The greatest concentration is found on alluvial soils (Table 4).

The alluvial soils are found in the Indo-Gangetic plain and along the east coast at the mouths of the rivers. The soils of these deltas are usually clay and clay loams. They are not as heavy as the black soils, but contain more plant nutrients because of the additions of silt carried by the rivers. They are rich in potash and are fairly well supplied with lime but phosphate is not adequate. They are extremely poor in organic matter and deficient in nitrogen. They are mostly neutral in reaction.

The black soils are found over a large area of peninsular India. Unlike black soils of other parts of the world, the Indian black soils are low in organic matter. They crack heavily during summer, but swell up during the rains and become impervious. They are poor in humus, nitrogen and phosphate but are supplied with adequate amount of potash. They have a higher lime status and a high exchange capacity. They have an alkaline reaction with a pH varying from 8 to 9. With careful attention paid to drainage, these soils give a good yield of rice (Ghose *et al.*, 22).

The laterite soils are characteristic of the west coast

TABLE 9—RICE-GROWING SEASONS AND CULTURAL PRACTICES IN DIFFERENT STATES*

State	Crop season	Sowing time	Harvest time	Remarks
Assam	Ahu (Aus)	Apr.-June	Aug.-Sept.	Mostly rainfed & broadcast ; transplanting only in a small area
	Sali	June-July	Nov.-Dec.	
	Boro	Nov.-Dec.	Apr.	
West Bengal	Aus	Apr.-May	Aug.-Sept.	Rainfed ; second crop irrigated ; both broadcasting & transplanting followed
	Aman	June-July	Nov.-Dec.	
	Boro	Nov.-Dec.	Mar., Apr.	
Orissa	Beali	Apr., May	Aug.-Sept.	Mostly broadcast ; irrigation available for c. 25% of the area
	Sarrad	June-July	Dec., Jan.	
	Dalua	Nov.-Dec.	Mar., Apr.	
Andhra Pradesh	Sarava or abi	May-June	Oct., Nov.	Transplanted or broadcast ; irrigation available for c. 90% of the area
	Dalua or tabi	Dec., Jan.	Apr., May	
Kerala	Viruppa Mundakan Punja	Apr., Sept., Oct., Dec.-Jan.	Sept., Jan., Feb., Mar.-Apr.	Mostly broadcast ; transplanting done for second crop ; irrigation available for about half the area
Madras	Kar	May-June	Sept., Oct.	Mostly transplanted ; irrigation available for c. 85% of the area
	Samba	June-July	Dec.-Jan.	
	Navarai	Dec.-Jan.	Apr.	
Maharashtra & Gujarat	1st Crop	May-June	Oct., Nov.	Transplanted or drilled ; rainfed & irrigated
	2nd Crop	Dec.	Mar.	
Mysore	Haine	June	Dec.	Transplanted & broadcast ; irrigation available
Madhya Pradesh	2nd Crop	Jan.	May	
	Kharif	June	Oct.-Nov.	Mostly broadcast & rainfed ; transplanted under irrigation in some areas
Bihar	Aus	May-June	Sept., Oct.	Broadcast & transplanted ; mostly rainfed ; c. 30% area under irrigation
Uttar Pradesh	Aman	June-July	Nov., Dec.	Transplanted ; mostly rainfed & broadcast ; a small area under irrigation
	Boro	Dec.	Mar., Apr.	
Punjab	Kharif	June-July	Nov., Dec.	In hilly areas, mostly rainfed & broadcast ; in the plains, mostly irrigated & transplanted
Jammu & Kashmir	Kharif	June	Sept.	Grown in terraced lands ; mostly broadcast

* Ghose *et al.*, 414-17.

and are extremely poor in all the bases, particularly calcium and phosphate ; they are all acidic with a pH of about 5.

Red soils form the major soil group of the Indian Peninsula. They are light, porous, friable and contain small percentage of soluble salts. They are deficient in nitrogen, phosphorus and calcium and also humus. With irrigation and addition of fertilizers they can be successfully brought under rice (Ghose *et al.*, 21).

Alkaline soils are found in parts of Punjab, Uttar Pradesh, Bihar and Rajasthan and saline soils are found all along the sea coast, especially on the east coast where periodically the land is inundated and cultivable areas get submerged by sea water.

Saline and sometimes alkaline soils are also found in rice deltas and in low lying situations where drainage is defective. In spite of their being saline, these areas are also devoted to rice. The soluble salts present in the soil are mostly of sodium. They are easily reclaimed after one or two seasons by flooding with river water of low salt content and by suitable treatment of the soil with incorporation of green manure or paddy straw, application of gypsum and provision of suitable drainage (Ghose *et al.*, 22).

The problem of deciding the most suitable soil type for successful rice production is complicated by the interplay of a number of factors other than the soil itself. In actual practice rice is grown in practically all types of soils from sandy loams and shallow

laterite soils to heavy clays, the only limiting factor being water supply either by rain or irrigation. Subject to this limitation, heavy soils characteristic of river valleys and deltas are apparently better suited to rice growing than lighter soils (Ramiah, *Agric. Developm. Pap.*, FAO, No. 45, 1954).

One of the major factors of soil suitability is thought to be related to percolation and drainage. Heavy soils have enough clay to permit puddling and reduce loss of water and nutrients by excessive percolation and thus permit the development of the reduced state favourable to rice nutrition in the root zone. While excessive percolation is harmful, absence of water movement through the root zone is also undesirable, due to the chemical or biological production and accumulation of substances which would not normally appear in significant levels.

It is said that some seasons must elapse before a dry soil can be converted into a good quality paddy soil. Cultivation operations by man in non-peaty soils bring about a change in the profile which is analogous in effect to the naturally occurring impervious layer in peaty soils. These operations bring about what is known as a 'clay pan', a horizon of accumulation of stiff impervious clay. Apart from the chemical and biological changes involved, there is a redistribution of the particles between the soil and the subsoil, along with a rapid breakdown due to weathering, both in the soil and subsoil, causing the soil to slowly become heavier in texture than under the original dry condition. The length of time required to develop a clay pan subsoil under irrigated rice is supposed to be about 50 years, although some soils have developed the pan even within 20 years.

Besides texture of the soil, structure is equally important. At certain moisture levels, cultivation by ploughing or digging brings about a change in soil crumb structure, affecting the yield considerably. It has been shown that summer ploughing or deep digging in off season destroyed structure of deltaic soils and gave reduced yields.

A type of clay pan which develops frequently in wet land paddy cultivation is the 'plough pan', caused probably by the mobilization of silica in solution, produced during wet ploughing and precipitated later as a cementing agent (Ramiah, *Agric. Developm. Pap.*, FAO, No. 45, 1954; Mukherjee *et al.*, *Indian J. agric. Sci.*, 1950, 20, 1).

No indication is available regarding fertility status of soils from the analysis made of rice soils, with reference to their nitrogen, phosphorus or potash

contents. Soils with widely different nutrient contents have shown similar yields, while soils with the same quantity of nutrients have given widely varying yields. It is stated that chemical analysis gives only a rough indication of the nutrient status of the soil and sound nutritional requirements can be obtained only when analytical data are correlated with actual manurial trials.

An important factor in the rice soils is the *pH* which is a measure of the soluble salts present and their nature and ionizability. In almost all countries, the *pH* of rice soils is on the acid side, except in Upper Burma and West Pakistan, where the soil is definitely alkaline, with a *pH* of 8.0 to 8.5. In India, only the black soil groups in the interior have a *pH* of over 8.0; all other rice soils are just acidic or neutral and in the case of laterite soils fairly acidic. Experiments have shown that rice plant prefers a slightly acidic or neutral reaction of the soils; many of the micro-organisms which play a part in the mineralization of organic matter thrive best in a slightly acidic *pH*. The conditions under which rice is grown also contribute to the soil reaction gradually tending to a lower *pH*. Such soil acidification, following rice culture, is reported to be caused by the imperfect aeration and oxidation of organic matter.

Under flooded condition, a paddy soil develops a profile consisting of: (1) a thin oxidative layer, brownish in appearance, varying in depth from a few millimetres to one centimetre; (2) a bluish reductive layer below, extending through to a depth of plough slice; and (3) the rhizosphere near the roots, which again is an oxidized layer. When the rice field is drained, the conditions are changed. The entire furrow slice which was reductive becomes oxidized, and for some time the activated heterotrophic organisms there rapidly decompose the organic matter producing ammonia, which is nitrified by the auto-tropic organism active in the oxidized layer above. When the field is reflooded and becomes waterlogged, the nitrates produced in the oxidized layer get denitrified, and are then leached down to the reduced subsurface layer. This finding of an oxidation-reduction potential layer, a short distance below the soil surface in a flooded paddy field is said to be of very great practical importance. In paddy soils, where concentrated nitrogenous manures like ammonium sulphate, fishmeal and oilcakes are added to the upper layer of paddy soil, the loss of nitrogen by nitrification in the oxidized layer of the soil and subsequent denitrification in the reduced

layer may be very great. It has been calculated that under adverse conditions these losses from a flooded soil amounted to nearly 70% of the nitrogen added as fertilizer to the crop and this finding has led to important studies on the time and placement of fertilizers (Nagai, 515-17).

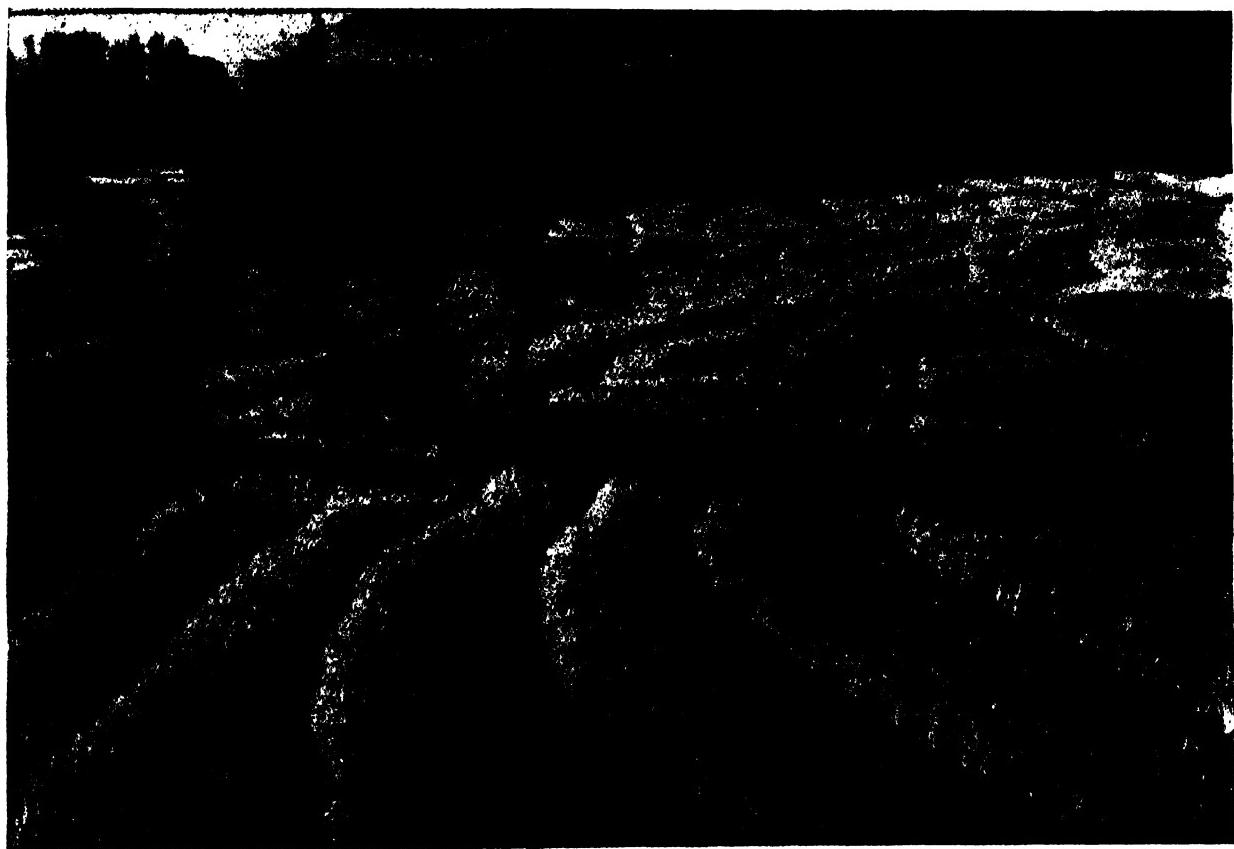
CULTIVATION PRACTICES

Cultivation of rice can be considered under two main heads: lowland rice (Wet paddy cultivation) and upland rice (Dry paddy cultivation). There is also a semi-wet rice, where the crop is raised as a dry one to begin with, but gets flooded with rain during growing period. Lowland rice forms the major portion of the rice cultivated in India and elsewhere and is confined to lowlands fully inundated with water from the time of planting or transplanting until harvest approaches. Its characteristics and cultivation form the major aspect of rice cultivation and are dealt with later (Ghose *et al.*, 40; Subbiah Pillai, 3-4; Grist, 113).

UPLAND RICE

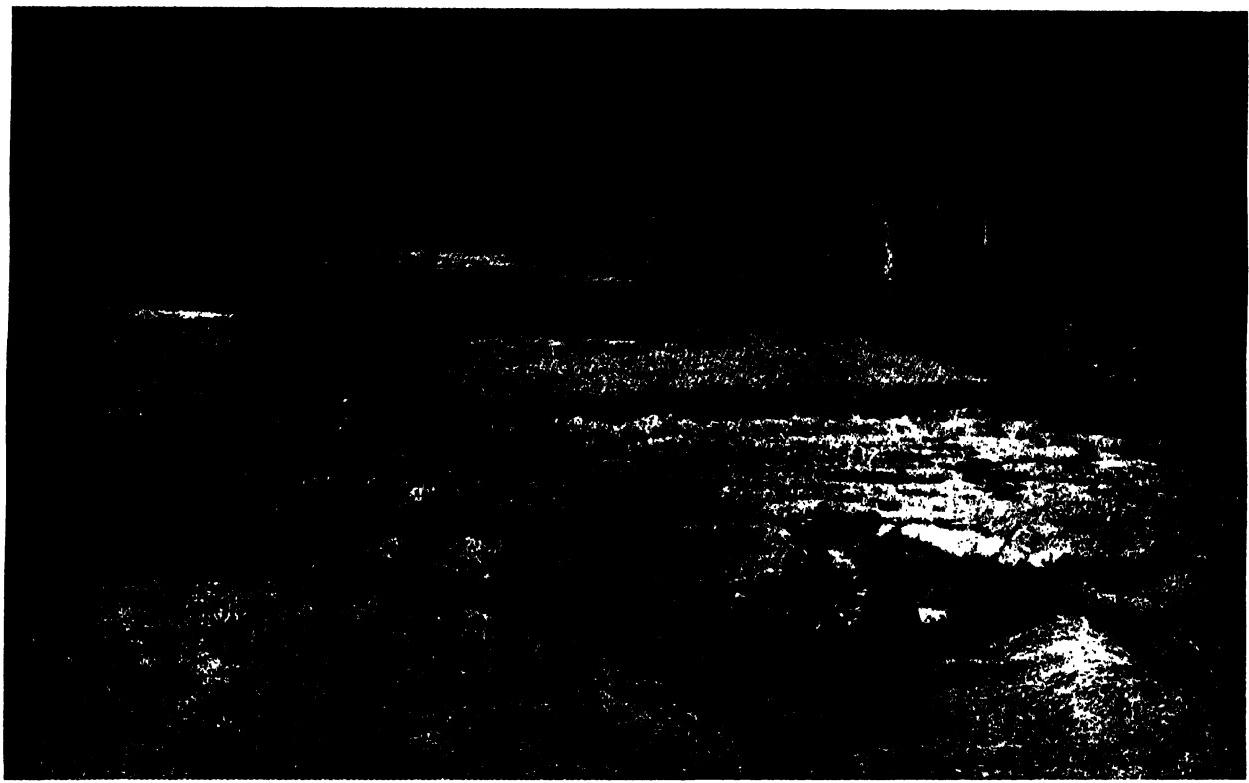
Upland rice is of much less importance and forms hardly 10% of the total rice area in Asia ; it is somewhat important only in Philippines and Indonesia. Upland rice is grown on hill tops, hill sides or other areas, where neither irrigation nor any device to hold rain water on the land exists except some amount of terracing. Upland rice grows and matures with rains like other dry crops. In typical upland rice the soil is not saturated with water and its successful cultivation mainly depends upon the amount of rain received and its distribution. In India, typical upland rice cultivation is confined to small areas in the hill tracts of Jammu & Kashmir, Punjab, Uttar Pradesh, West Bengal, Assam, Orissa, Andhra Pradesh and Kerala (Subbiah Pillai, 3-4 ; Ghose *et al.*, 40).

The seeds are sown either broadcast or by drilling or dibbling in plough furrows. Upland rices are generally of short maturation period (90-120 days) and have a well developed and larger root system and a significant tolerance to drought. The grain is



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FIG. 53—RICE FIELDS IN KASHMIR



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FIG. 54—RICE FIELDS IN HIMACHAL PRADESH

generally coarse, broad and bold and may also have a red coloured kernel, though their eating quality may not be poor. In fact some upland rices of Thailand and Orissa (India) are considered to be of high eating quality (Subbiah Pillai, 13-19; Ghose et al., 45).

The yield of upland rice is generally low even when rains are normal and well distributed. Under the tropical conditions, the soil under upland rice loses its fertility rather rapidly, while in lowland rice even with no fertilizers yields are maintained, though at a low level, because the flooded condition of the soil renders it richer in nutrients. Another difficulty with upland rice is the abundance of weeds. To obtain satisfactory yields with upland rice the soil fertility must be maintained by suitable crop rotation or addition of fertilizers, along with control of weeds. Ordinarily, a long fallow of 2-3 years, as in Kerala, is practised which prevents loss of fertility. In parts of India where upland rice is grown in heavy soils, 3 to 5 rows of short maturation rice are interplanted with 2 rows of cotton or *arhar* (*Cajanus cajan*);

sometimes rows of the Italian millet (*Setaria italica* Beauv.) may also be included to be harvested at the same time as rice. Rice benefits considerably when it follows groundnut in rotation.

Shifting cultivation or 'Fire Farming' is the most destructive and wasteful form of growing upland rice and is practised mostly by hill tribes in parts of Asia and Africa. In India, it is practised to some extent in Kerala and Assam where it is known variously as '*punam*', '*podu*', or '*jhoome*'. The most common feature of this system is the felling of trees and shrubs on top or slopes of hills, burning them *in situ* and growing rice in the cleared ground for a period of years, abandoning the places when yields become low and taking to other parts of forests for similar treatment, but coming back to the old patches after a lapse of several years—often more than 10-15. The fall in yield in those areas is due not only to loss of fertility, but also to the gradual invasion of the cleared patches by perennial weeds. In the cleared patches rice is dibbled in holes made with a stick and the crop takes care of itself until it is harvested. In

this practice, rice may be grown alone or mixed with other crops like maize, gram, chillies or vegetables. This wasteful practice has been stopped in places where administrative control has become effective ; steps have also been taken to regenerate forest growth by suitable sylvicultural practices.

FLOATING RICE

In West Bengal, Assam, Orissa, Madras and Kerala, there are some low lying areas where during the later part of the rice season water accumulates to a depth of 0.5–1.5 m. In these areas only floating types, which can tolerate considerable depths of water, can be grown. The land is ploughed when dry, and the seed is sown broadcast, taking advantage of an occasional rain or even with the existing soil moisture. The crop comes up like an upland rice and when the monsoon strengthens and rivers get flooded, the crop grows up rapidly, keeping pace with the rise in water level. When the water level becomes stationary, the growth ceases and is followed by tillering and rooting at higher nodes. The maximum growth that has been recorded is about 52 cm. in 4 days. Types differ considerably in their growth rate in response to rise in water level and selection of a particular type is decided by the total height to which it can grow. Stem of floating rice has a strong mechanical system to enable it to withstand uprooting and lateral stress in strong currents of water. All floating rices have a long maturation period, 7 months or more. Generally, water does not recede sufficiently when the crop is ripe and hence harvesting of heads has to be done in standing water from boats.

LOWLAND RICE

By far the greater area planted with rice is on low land subject to seasonal flooding or where there is an assured and adequate supply of water. The crop is mostly transplanted and is of 5-6 months duration.

Sowing—In wet rice cultivation, the seed may be sown either directly in the field or sown first in a nursery and the seedlings later transplanted. Trials in India and other countries have shown that transplanting is better than direct sowing, giving 15-25% more yield ; but its success will depend upon an assured and regulated supply of water and extra supply of labour.

Direct sowing is adopted, either in the absence of water control or due to non-availability of labour. It

may be done by broadcasting or drilling or dibbling the seed behind the plough furrow. The first operation can be either in the wet or dry soil, but the other two can only be in the dry soil. For wet sowing the usual practice is to soak the seed sufficiently to sprout it before sowing. Even in dry sowing, the seed may have to be soaked in water for a short time to hasten germination in the field. In wet sowing, which is done in standing water, the preparation of land extends over a few weeks. Actual sowing is done over a few centimetres of water as otherwise sprouted seeds may sink into soft mud and germination is affected. In dry sowing, the seeds are drilled or sown in plough furrow and immediately covered. Optimum depth of sowing depends upon the nature of the soil : it may be 5-6 cm. in a light loamy soil but in heavy clays, it should not be more than 2-3 cm. The land is usually left slightly rough ; if the land is not to be flooded immediately a plank or beam is passed over to compact the soil with a view to stimulate germination.

The amount of seed used for direct sowing varies widely from 60 to 200 kg./ha., depending upon the conditions of soil and water control. In many Asian countries a seed rate of 60-70 kg./ha. has been found quite satisfactory, although it is somewhat higher in the temperate rice growing regions in U.S.A., Italy and Australia (Subbiah Pillai, 30-32).

In India and in Japan, active investigations are in progress to evolve a direct sowing technique comparable in performance to transplanting. Sowing dry seed in lines behind the plough furrow in the dry soil was found as good as transplanting and better than broadcasting. This is in line with some of the earlier investigations in India and elsewhere where drilling was comparable to transplanting and better than broadcasting. But favourable conditions for direct sowing may not obtain in many areas. The soil is usually heavy and dries up so hard after rice harvest that it cannot be tackled until it gets flooded again. The alternative will be to prepare the puddle and sow the seeds in lines in the soft puddle. In experiments conducted in this country, comparing direct sowing of sprouted seed in lines in the puddled soil, against broadcasting and transplanting, line sowing was invariably better than broadcasting and was as good as transplanting. But to adopt this practice in large scale agricultural practice a simple seeder to sow the seed to the right depth in a soft puddle is a necessity. More than this, there is a great need for good water control to regulate carefully the

draining and irrigation of the directly sown plot in the earlier stages [Subbiah Pillai, 1959; Narahari & Pawar, *Rice News Teller*, 1961, 9(3), 15].

Choice of varieties—The growing of a variety is mainly determined by climatic conditions, water facilities, agricultural convenience and local demand. In rice areas of South India, Java and Ceylon, where rice is grown all through the year, it is the period of water availability that determines the choice of variety to be grown, i.e. early, medium or late*; where two crops of rice are raised on the same land, one of them will be an early maturing type and the other a medium or late maturing type. In areas subject to floods and where floating rice is grown, the type is always of a longer maturation period. In areas where rice is grown in terraces on hill slopes, the actual position of the rice fields in the slope determines the choice of an early, medium or late type. In the case of upland rice, where the crop depends entirely on rains, the types grown are invariably of a short or medium maturation period.

In the warm temperate regions rice cultivation is confined to the summer season and generally medium maturation rices (140-150 days) are grown. In the tropical regions late planting is often unavoidable because of either delayed monsoon or the early planted crop getting damaged by floods. It is therefore necessary to have rices which do not become unduly early or late or suffer in yield by late planting.

It is sometimes stated that with water facilities available for a period of 6-7 months, it would be more economical to grow one late maturing variety, and not two varieties of shorter maturation periods. However, records show that with the right choice, two early maturing crops are generally more profitable than one of a longer maturation period.

Sowing date—Experimental data available in India show that the generally accepted finding—the earlier the planting the larger the yield—need not be true in every case. Many varieties, when planted too early, get their maturation period extended and such extension contributes only to a larger yield of straw and not of grain. There are also varieties which give satisfactory yield in spite of any reduction in maturation period resulting from late planting. Each variety, irrespective of the change in the maturation period,

has an optimum period of planting when production is at the maximum and the optimum period may be as short as a few weeks or as long as 2 or 3 months.

Raising seed beds—There are three principal methods of raising seed beds, the dry, the wet and the semi-dry, the last being a minor variation of either the dry or the wet method.

The dry seed bed is prepared in soils with sufficient moisture. It is moderately manured mainly with organic manure and wood ashes. The seeds are sown broadcast or behind a plough furrow. If the soil moisture is not enough, a light irrigation may be given. After the germination is complete, light irrigations are given once in 4 to 8 days according to the nature of the soil. The seed rate may vary according to the size of the grain from 1 to 2 kg. of seed for 20-35 sq. m. of area of seed bed (Subbiah Pillai, 28).

A variation of the dry seed bed, called the 'rab' system is adopted in western India, where the soil is sticky and hard. The seed bed is covered with brushwood, twigs, dry leaves and cowdung and burnt. This method, while it sterilizes and makes the top soil friable, however, is highly wasteful as cattle manure and compost give equally good results (Subbiah Pillai, 33).

The seedlings from dry seed bed are harder and can remain in the nursery even up to 70-80 days by restricting water supply. Raising of dry seed beds is practised in India, Japan, China, Thailand, Philippines, Indonesia and Pakistan.

The semi-dry seed bed system is practised in Madras and in parts of Godavari delta (Andhra Pradesh) for raising seedlings where there is a shortage of water supply either before or after sowing. The seed bed is first prepared as a wet seed bed and sprouted seed is sown and treated as in wet seed bed for the first 3 weeks. The water supply is then cut off completely and the bed allowed to dry up. The seedlings start withering and appear as if scorched. Two to three weeks later the seedlings are uprooted in the dry condition and left in bunches in wet puddled soil for about 2 days, when the plants put up new roots profusely, and they are then transplanted. By this practice the crop is said to mature not only two weeks earlier than when ordinary seedlings are transplanted, but also show no reduction in yield.

Wet seed bed is the more common method followed wherever rice is grown under irrigation and also in rainfed areas of the tropics. Here the land is first flooded and puddled with plough or harrow, as in the

* The terms early, medium or late are only relative. An early type of one country may actually correspond to a medium or late type of another country and vice versa. An early type would mean a maturation period of 90-100 days in India and Pakistan, 120-130 days in Japan and 155 days in Malaya.



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FIG. 55—PLOUGHING OF WET RICE FIELD

case of transplanted fields. It is also manured with green leaves or other organic manures. The most important operation is to press the soft mud uniformly by planking and get a uniform level. Laying the nursery area in long and narrow beds slightly raised in level, with drains all round, facilitates irrigation and draining. Such narrow beds also facilitate proper levelling of the surface. Water is allowed to stand continuously in the bed only after the seedlings have grown about 15 cm. tall. About 25 kg. of seeds sown in about 400–500 sq. m. yield enough seedlings to transplant one hectare.

In areas of saline land along the west and east coast, rice cannot grow until the beginning of monsoon; so the land is ploughed before the South-West monsoon starts and the top soil is gathered into several small mounds 60–120 cm. in diam. and about 60–120 cm. high. With the first showers the salts in the mounds get washed out, and after stirring the top soil and manuring, sprouted seeds are sown on the mounds. The seedlings grow rapidly and when about 40–50 days old the mounds are cut up into small bits with a few seedlings in each and distributed evenly

throughout the field. The mounds disappear and the whole field is covered with seedlings (Ramiah, 73–74; Ghose *et al.*, 52).

Several other methods of raising seed beds adapted to particular local conditions are to be found in the different rice growing areas of the world. In the 'dapog' seed bed of Philippines, a layer of fresh banana leaves is pressed down into the mud of the nursery bed and a layer of chopped rice straw and compost spread over it. Sprouted seed is sown thickly on this and the seedlings are pulled out for transplantation in the field when they are only 10–12 days old. In the floating seed bed of parts of Malaya, mud is plastered on to long beds of grass cut and piled to a height of 2.5 cm. above water level and over the compact bed seeds are sown later. The seedlings which are 25–30 cm. high when 12–16 days old are pulled out in clumps and transplanted one or more times before they are finally planted by which time they are 80 days old and 60 cm. in height. In Bali Island, whole panicles of the *Bulu* rice are sown in rows in the field and covered with earth. In northern Japan where the nursery is raised early in the season,

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when it is too cold for seed to germinate, the seed is soaked overnight in warm water and allowed to sprout in warm conditions. It is then sown on beds and covered with fine soil and burnt rice hulls over which oil paper or alkathene sheets are spread to prevent the cold air getting in. A similar system is said to have been successfully tried in Andhra Pradesh to start the nursery earlier than usual in the cold weather.

Grain used as seed should be heavy and well developed. Selection of heavy seeds may be done by soaking the seed in salt solution with a specific gravity of 1.10–1.13 and removing all light seeds which float up. Sometimes, instead of salt a thin mixture of clay and water is used for the purpose. Experiments in India, however, have not established the advantage of selecting heavy seed for planting, except in varieties with a short maturation period. Heavy grain of uniform weight will no doubt give uniform and rapid germination in the seed bed, which is an advantage (Grist. 117; Subbiah Pillai. 34–35).

As a prophylactic measure, seeds are disinfected before sowing with fungicides like formalin or mercuric compounds to destroy all seed-borne diseases. Where seeds have to be sprouted before sowing, the seed is put in a sack tied loosely and kept immersed under water in a stream or tank for about 36 hr., when they absorb water to the extent of nearly 25% of their weight. The soaked seeds are then kept in the bag or heaped in a dark room covered over with wet sacking and stirred occasionally, with water being sprinkled if necessary. In 24 to 36 hr. the grains start germinating and the right stage for sowing is when the radicle is just showing out and is not more than 3–5 mm. (Subbiah Pillai, 24–26).

Rice grain can germinate either immediately after harvest or may require a period of dormancy. Among Indica rices, those with a short maturation period of less than 120 days do not generally have a dormant period, while varieties which have a long maturation period of 160 days and more require usually a resting period of 2–4 months. The period of dormancy can be broken even in varieties which require a dormant



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FIG. 56—LEVELLING THE PUDDLED RICE FIELD



FIG. 57—PREPARATION OF SALINE LAND FOR RICE GROWING IN KERALA

period by smoking the seed. Rices which have no dormancy can also lose their viability quickly. Preserving the viability of early maturing rices is a problem in many rice growing countries. Grains with less than 10% moisture stored in airtight receptacles retain viability indefinitely. The presence of seed dormancy in high yielding, medium and late duration varieties prevents, however, the raising of a second crop even where appropriate conditions are available. The impervious nature of the hull is considered to be the possible cause of this dormancy which can be broken by hulling or treatment with some chemicals to give improved germination [Ramiah, 104; Butany & Gangadharan, *Rice News Teller*, 1958, 6(4), 9].

External conditions that influence germination are temperature, moisture and oxygen. Rice can germinate from 18 to 45°, the optimum being 35–37°. In temperate regions the maximum, minimum and optimum are somewhat lower. Under the same conditions, varieties can differ in the rapidity of germination and Indica rices germinate faster than Japonica

rices. Some finish germination by 2–3 days after sowing while others take about a week, the rapidity of germination being probably related to the thickness and hairiness of the husk.

TRANSPLANTING

Transplanting is an improved agronomic practice followed since very ancient times; it is one of the hardest and most expensive operations connected with rice culture. Rice growers believe that transplanting makes the plants more productive than broadcasting; other advantages claimed are: suppression of weeds by puddling; greater root development due to root pruning; greater encouragement to tillering; protection from incidence of unfavourable weather during sowing and growth; and protection from attack of thrips and other pests in early stages. Transplanting is practised in nearly four-fifths of the rice growing areas in the world and almost all countries where highest yields per unit area are recorded have adopted transplanting (Subbiah Pillai, 19–24).

Before transplanting, the land is given a thorough preparation, involving repeated ploughing, manuring and puddling in order to get a soft puddle. Rice fields of sand or sandy loams are ploughed in summer, while heavy clayey soils are usually ploughed with 5 cm. of standing water a few days before transplanting. The number of ploughings required for the dry crop or wet crop depends upon factors like nature of the soil, time of opening of the land, the degree of weathering of the soil during fallow period and the kind of ploughs and implements employed. The only criterion that guides in the preparation of land for the dry sown rice crop is to obtain a good tilth for receiving the seed and for the wet crop, a soft puddle for the transplanted seedlings to anchor themselves and establish quickly (Subbiah Pillai, 4-11).

Generally, heavier soils are ploughed somewhat deeper than lighter soils. In the heavier soils the hard pan below has to be occasionally broken up to improve downward movement of water, whereas in the lighter soil the pan should not be disturbed, lest it should bring about too rapid percolation. Even

where deeper ploughing has been found useful it is not necessary to do it every year. The optimum depth in most cases is 10-15 cm. Deeper ploughing is useful in lands infested with perennial weeds. Where green manuring is practised, however, the land has to be cultivated deeper to incorporate the green matter into the soil. Work in Japan indicates that with larger use of chemical fertilizers deeper ploughing becomes necessary. It is possible that the present prevalent opinion that deeper cultivation is not necessary may have to be changed when green manuring and use of chemical fertilizers become more common.

Factors influencing the success of a transplanted crop are the age of the seedling at transplanting, the time of planting during the season, the spacing allowed between plants and the number of seedlings planted per hole. Generally, the earlier the planting the greater the yield. But each variety has an optimum range of planting time with reference to a particular rice area and any planting beyond this range, particularly on the later side, affects yield adversely, and within limits such an adverse effect can



FIG. 58—RICE SEED BEDS

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FIG. 59—REMOVING RICE SEEDLINGS FOR TRANSPLANTING

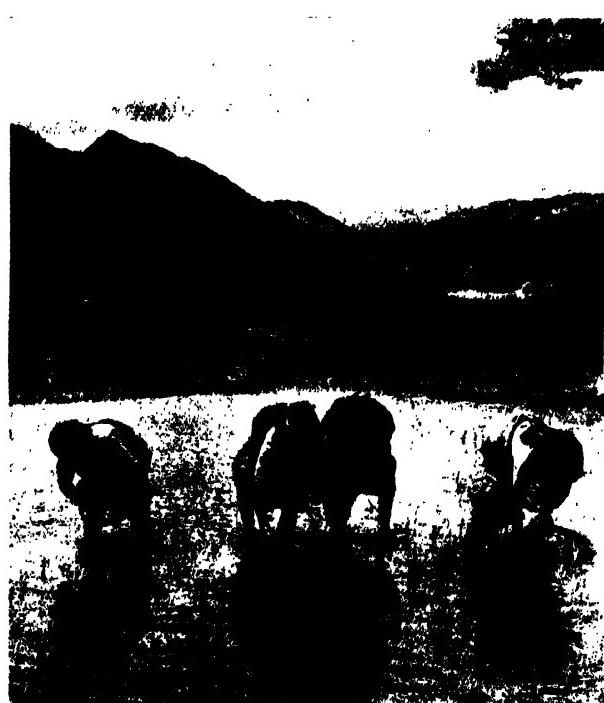
be counteracted by adjustment of cultural practices such as age of seedling, spacing and number of seedlings per hole and increasing the fertility of the soil by additional fertilizing. In areas where no water control is possible and rice growing has to depend on unpredictable water sources, a dry seed bed is preferable to wet seed bed (Subbiah Pillai, 45-62).

The age of the seedling to be planted varies from 20 to 50 days according to the maturation period of the variety. There is no harm in planting a seedling younger than 20 days provided the level of water can be controlled, but planting seedlings older than 50 days is not beneficial even where the varieties are late maturing. The optimum age of seedlings is somewhat lower in the warmer tropics than in the colder temperate regions. In Japan and Italy, 45-50 days is considered an optimum, whereas for varieties which have a similar maturation period in the tropics, 30-35 days is the optimum. In tropical countries the right stage of the seedling for planting is decided by the age and growth of the seedlings, but in Japan the right stage is determined by the number of leaves in the seedling; five to six leaf stage is considered the right condition for early types and 6-7 leaf stage for the later types, since at this stage the plant makes best use of the nutrients added to the soil. No such information is available under Indian conditions (Subbiah Pillai, 36-38 ; Grist, 120).

The spacing allowed between plants depends upon

the type, fertility of the soil and season. In most of the trials, closer spacing has always given higher yields than wider spacings. For tropical conditions the optimum spacing is never more than 20-25 cm. and can be reduced to even 15 cm. with varieties whose duration is about 150 days. For still earlier varieties maturing within 100 days, the optimum spacing is only 10 cm. The spacing and number of plants per hole are compensating characters to be adjusted according to needs. In Japan with intensive use of fertilizers spacing up to 30 cm. is allowed in fertile soils. Practically all varieties grown in the tropics have weak straw, and closer spacing though desirable from the point of view of potential yield results in premature lodging and loss in yield. A slightly wider spacing than the optimum may, therefore, be desirable to prevent premature lodging [Subbiah Pillai, 38-43 ; Vachhani *et al.*, *Rice News Teller*, 1961, 9(2), 15].

It is usual to plant 8-10 or more seedlings per hole in many countries of South-East Asia. Planting more than 3-4 is unnecessary and planting 1-4 seedlings does not make a difference in final yield, except as an insurance against possible casualties ; the straw yield is somewhat higher with 3-4 seedlings than with a single seedling. With strong seedlings raised



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FIG. 60—TRANSPLANTING RICE

in a thinly sown nursery, the number planted per hole can be reduced to the minimum (Subbiah Pillai, 44-45).

Transplanting is done in regular lines in Japan, S. Korea, Taiwan and Indonesia but not in other South-East Asian countries including India. It is doubtful if planting in lines by itself confers any benefit except indirectly by facilitating weeding. In Italy and Egypt where the seedlings are not planted in lines, rice yields are still as high as or even higher than in Japan. The introduction of the Japanese method of rice cultivation in India has led to row planting and interculturing between rows and the practice has proved of some advantage in many centres. The benefit must, however, be attributed only to interculturing, which is easily possible when the crop is planted in lines. Other benefits claimed are, prevention of lodging, protection against rat damage, better control of irrigation and drainage and application of plant protection methods against diseases and pests.

Besides the above normal practice, there are

certain transplanting techniques which are adopted to get over some practical difficulties. The top portion of the seedling is sometimes pruned at the time of planting in order to prevent the seedlings getting uprooted by strong winds soon after planting and also to minimize transpiration. A certain amount of pruning of roots does occur under natural conditions when seedlings are uprooted for transplantation. Experiments on the effect of severe root pruning of seedlings at the time of transplantation are said to show that such pruning makes no difference in yield in the case of medium and late types, but is not desirable for very early maturing types. In the Japanese method of rice cultivation, care is taken to see that least damage occurs to the seedling roots at the time of removing them from the seed bed. The transplanted seedlings take generally a week to establish themselves and start producing new roots, leaves and shoots (Subbiah Pillai, 63-64).

*Other modes of transplantation--*Pulling out seedlings one day and transplanting them the next day is almost the universal practice. Seedlings held



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FIG. 61—TRANSPLANTING RICE SEEDLINGS IN ROWS (JAPANESE METHOD)

over for more than 3 days after removal from the seed bed failed to establish satisfactorily; any period beyond 5 days affected tillering and yield. A special practice followed in parts of S. India, of heaping the seedling bundles in a circular heap for 3-4 days before transplanting is said to destroy egg masses and young insects which otherwise infest the crop later (Subbiah Pillai, 62, 64; Grist, 126).

Double transplantation is said to be followed in some areas like Godavari delta with varieties of long maturation periods of over six months. It is adopted in areas where early planting is either not feasible or results in excessive vegetative growth and also where it is desired to hasten flowering in order to get early harvest. Experiments with double transplanting show that it can be recommended for tracts where late planting is inevitable for one reason or other (Ramiyah, 70-72; Subbiah Pillai, 65-68).

In parts of Madras, Kerala and Assam, two varieties of rice, one of a short maturation period of about 100 days and the other of a long maturation period of 180-210 days, are sown mixed in the proportion of about 3:1. The mixture may be sown in a seed bed and transplanted as in Madras or broadcast directly in the field as in the other two States. In Madras the early crop is harvested in September, when the late type is still in foliage and gets a pruning; the late crop matures towards the end of January. While the yield of the two crops together does not compare with the yields of the two crops when grown one after the other, it ensures a certain measure of economy in the preparation of the land, raising of seed bed and transplanting. Further, it was always found that when the early crop is poor the late crop makes it up, so that there is not much variation in total yield from year to year. However, in mixed cropping, it is necessary that one of the types chosen is insensitive to photoperiod; usually the early maturing type is insensitive.

LATER CULTURAL OPERATIONS

When the transplanted rice crop has established itself, the other operations that need attention are weeding and interculturing, application of manures and fertilizers, and regulation of water supply.

Weeding is not generally practised in South-East Asia. In transplanted lowland rice weed infestation is comparatively less than in upland rice. In the ill drained areas where the soil never dries out in the off season there is a luxuriant growth of weeds, mainly aquatic sedges which have to be cleared

before planting rice. Such areas occur in West Bengal and Assam where floating rice is grown.

In an experiment with transplanted rice, the weeded plot gave 30% more yield than the unweeded plot. The loss in crop due to fields getting infested with wild rice (*O. rufipogon*) in India is estimated at 5-20% in Madhya Pradesh and 50-60% in Kangra in Punjab. In India, the menace of wild rice is being met by growing special types with pigmented foliage, from which the non-pigmented wild rice and the hybrids between the two can be distinguished and removed at the time of weeding.

A large number of weeds, both broad leaved and narrow leaved, have been recorded. Among the weeds of lowland rice, the *Cyperus* spp. are the most common. *Echinochloa crus-galli* (Barnyard grass), an annual grass, is the most troublesome and widely spread weed of lowland rice. The seeds of this grass get harvested with rice, and unless the rice seed is properly cleaned before sowing, the weed seed also gets back to the land. In the early stages it is difficult



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FIG. 62—INTERCULTURING RICE CROP WITH ROTARY WEEDEER.

to distinguish it from the rice plant. Some algae, particularly *Chara* spp., also do harm to the rice crop by forming a thick matting on the surface and affecting tillering of the young rice plant.

Control of weeds can be obtained by employing measures of a cultural, mechanical, biological or chemical nature. In lowland rice thorough puddling by repeated ploughings or harrowings can reduce the weed population considerably. Where dry sowing is practised, it may be useful to use a drill instead of broadcasting, thus facilitating harrowing. Deep ploughing once in 2-3 years is necessary in areas where floating rice is grown. In case of perennial weeds, ploughing early in the season and exposing the roots of weeds to sun for 2-3 months in the dry period helps in their control. In U.S.A. and Australia, control of weeds other than aquatic plants and a few grasses is obtained by controlling the depth of water in the fields, as most of them are killed by submersion.

The simplest method of mechanical control is hand weeding. In lowland rice, bullock drawn spike harrow is the most widely used implement. Weeding receives the greatest attention in Japan and special types of handworked or animal drawn rotary weeders have been developed. They not only remove weeds but also bury them and stir the soil round the plants. Experiments in India have shown that this stirring of the mud in the early stages does confer some benefit, particularly in inducing more tillering.

Chemical control of weeds by use of hormones has become a regular practice in U.S.A. In Japan, 2,4-D is now being regularly used on 20% of rice area. This is effective mostly with the broad-leaved weeds. Other synthetic hormones found useful as weed killers are 2,4,5-T and MCPA. These herbicides are applied at three stages of paddy cultivation: pre-planting, pre-emergence and post-emergence. Hand weeding is still the only method available to control barnyard grass (*Echinochloa crus-galli*), an important weed of rice fields. For controlling *Chara* spp., application of 11-16 kg./ha. of copper sulphate has proved effective.

Experiments conducted at Central Rice Research Institute, Cuttack, have indicated usefulness of Chloroxone, Phenoxylene-30, and 2,4,5-T. 4-6 weeks after transplanting was found to be the optimum time for spraying; MCPA spraying was the most efficient. Experiments comparing the use of herbicides with hand weeding and Japanese rotary weeder have

shown that the use of the latter appears to be most economical (Ghose *et al.*, 208).

Good preparation of land and adoption of improved cultural practices are still the high measure of weed control. In areas planted in regular rows, use of the Japanese rotary weeder has been very beneficial. Use of herbicides at the most reduces number of hand weedings, as they are effective mostly against broad-leaved weeds and not grasses.

Usually greater weed infestation is seen in the broadcast crop raised under dry conditions than in the transplanted crop. In parts of Assam, Bihar, Orissa and Madhya Pradesh an interculturing operation known as 'bushening' or 'biasing' is said to be extensively in vogue and very useful in cutting the cost of weeding (Subbiah Pillai, 74).

CROP ROTATION

In most of the States in India rice follows rice, and in some areas with good water facilities, two or even three rice crops are raised in the same land in one year. In the higher level delta areas with irrigation facilities and good surface drainage, cash crops like sugarcane, turmeric and banana are rotated with rice, once in 3-4 years. Growing of a leguminous crop in the off-season is, however, the most common practice. The kind of legume grown, however, depends upon the soil and climatic conditions. The crops cultivated most commonly are: gram, pea, *khesari*, lentil, green gram, black gram and horse gram. The other crops cultivated in rotation with rice in one or the other parts of this country are: berseem, potatoes, vegetables, jute, kenaf, ragi and cotton (Ramiah, 82; Ghose *et al.*, 51-52; Parthasarathy, *Farm Bull., Indian Coun. agric. Res.*, No. 1, 1954).

Rotation is generally practised only with regard to the upland rice. On most of the lowland areas, the land remains fallow after the rice crop. With no general practice of manuring the rice crop, this fallow enables a steady level of production, though low, with little variation from year to year.

MANURES AND FERTILIZERS

A rice crop, producing c. 3,360 kg. of grain and an equal quantity of straw from a hectare, removes from the soil roughly 54 kg. of nitrogen, 26 kg. of phosphoric acid and 46 kg. of potash. It is essential that sufficient quantity of manures, either in the organic or in the inorganic form, should be added not only to replenish the nutrients utilized, but also to keep the

fertility of the soil at a high level in order to get sustained high yield (Subbiah Pillai, 76).

NITROGEN

An outstanding result from all experiments on application of organic manures and fertilizers has been the universal response of rice to nitrogen in some form or other. The bulky nitrogenous manures used are cattle or farmyard manure, green manure, sludge manure, guano, compost, oilseed cakes, etc., while the commonest fertilizer used is mostly ammonium sulphate. The beneficial effect is determined not only by the form in which nitrogen is applied, but also the stage at which it is applied.

Organic manure—Oilseed cakes like those of castor, groundnut, sesamum, coconut, mustard and rape seed have all been used by rice growers and experiments have indicated that differences among them are negligible and their choice generally depends upon relative cost and availability. Further, comparison of oilseed cakes with ammonium sulphate is stated to have shown that on the same nitrogen basis, oilseed cakes are as efficient as ammonium sulphate at almost all the places and in some stations even better [Sethi et al., *Bull. Indian Coun. agric. Res.*, No. 38 (Revised Edn), 1952, 1-122].

Green manure—Green manuring practice is more prevalent in India than elsewhere and it is particularly common in the deltaic areas. There are several green manure plants suited to different conditions and areas, and a list of them is given in Table 10. Of these, Sunn hemp (*Crotalaria juncea*), Dhaincha (*Sesbania sesban*), Kolinji (*Tephrosia purpurea*) and Pillipesara (*Phaseolus trilobus*) are the most important. Where facilities for growing the green manuring crop *in situ* do not exist, weeds growing wild in waste lands, both leguminous and non-leguminous, are collected and turned into the soil; where forests or waste lands abound, loppings of trees are also used for the purpose; often even avenue trees in rural areas are not spared. Investigations are in progress on other green manure crops, both indigenous and introduced, and of the latter *Aeschynomene americana* and *Phaseolus lathyroides* have proved promising (Sethi et al., loc. cit.; Subbiah Pillai, 77-78).

Generally, the young green manure crop ploughed in has a fairly narrow C/N ratio and as such is said to have a quick fertilizing value, giving a higher yield response than other bulky organic manures like compost and cattle manure. Experiments to compare different green manure crops as well as to

TABLE 10—PLANTS USED FOR GREEN MANURING RICE

Crops grown <i>in situ</i>	<i>Crotalaria juncea</i> ; <i>Cyamopsis tetragonoloba</i> ; <i>Dolichos biflorus</i> ; <i>Lens culinaris</i> ; <i>Melilotus</i> sp.; <i>Mucuna deeringiana</i> ; <i>Phaseolus aureus</i> , <i>P. mungo</i> & <i>P. trilobus</i> ; <i>Sesbania cannabina</i> & <i>S. speciosa</i> ; <i>Tephrosia purpurea</i> ; <i>Vigna sinensis</i>
Weeds gathered and applied	<i>Adhatoda vasica</i> ; <i>Calotropis gigantea</i> ; <i>Cassia auriculata</i> & <i>C. tora</i> ; <i>Croton sparsiflorus</i> ; <i>Eichhornia crassipes</i> ; <i>Ipomoea carnea</i> ; <i>Lantana camara</i>
Leaves of trees commonly used	<i>Albizia lebbek</i> ; <i>Alysicarpus belgaumensis</i> ; <i>Azadirachta indica</i> ; <i>Cassia siamea</i> ; <i>Emblema officinalis</i> ; <i>Giricia sepium</i> ; <i>Delonix regia</i> ; <i>Strychnos nux-vomica</i>
Plants recommended for tidal areas	<i>Bruguiera conjugata</i> ; <i>Derris trifoliata</i> ; <i>Dolichandrone spathacea</i> ; <i>Excoecaria agallocha</i> ; <i>Kandelia candel</i> ; <i>Rhizophora mucronata</i>
Plants for saline rice tracts	<i>Crotalaria striata</i> & <i>C. verrucosa</i> ; <i>Rothia indica</i>
Plants for coastal sand banks	<i>Morinda citrifolia</i> ; <i>Pavetta indica</i> ; <i>Scaevola frutescens</i>
Other crops under trial	<i>Aeschynomene americana</i> ; <i>Phaseolus lathyroides</i>

find the optimum quantity to be applied have shown significant increases in yield in 61 out of 67 cases. The experiments were on the basis of nitrogen in the green manure and in ammonium sulphate, and the doses of nitrogen have varied from 11 to 66 kg./ha. The general finding is that green manure is as good as ammonium sulphate and, occasionally, green manuring with *Dhaincha* is even better than ammonium sulphate. About 6,600-8,800 kg. of green leaf per hectare appears to be the optimum at most places. There is no difference as to how the green manure is applied, whether the crop is grown *in situ*, or green leaves are brought from outside and applied: similarly between leguminous and non-leguminous plants. Green manuring with plants having sour leaves has proved useful in amelioration of alkaline soils. Response to green manuring is greatest in lighter soils than in heavier soils, while its practice is decidedly injurious under ill-drained conditions. Phosphate is applied to the leguminous green manure crops to stimulate their growth, thus enabling more nitrogen to be provided for the succeeding rice crop (Sethi et al., loc. cit.; Desai & Rao, *J. Indian Soc. Soil Sci.*, 1957, 5, 147).

Trials in Madras State have shown that there is an average increase in yield of 1 kg. of grain for every 15 kg. of leaf ploughed in, and that 5,500 kg. of green

leaf per hectare is about the optimum dose, and this will provide about 33 kg. of nitrogen per hectare.

Green manuring continuously over a number of years has not shown any cumulative beneficial effect, nor did it appreciably alter the C/N ratio of the soil. Evidence is, however, accumulating that with similar repeated applications of cattle dung or compost over several years there is a slow building up of the soil fertility. A comparison of the efficiency of different bulky organic manures shows that green manuring is superior to cattle dung, which in turn is superior to compost. Cattle dung increases mostly the straw yield; at lower doses it does not compare with ammonium sulphate. The chief utility of cattle dung and compost seems to lie in their cheapness when available in large quantities, and their adding to the soil other nutrients (Sethi *et al.*, loc. cit.).

Inorganic fertilizers—Investigations on absorption of nitrogen by the rice plant indicated that nitrogen absorption depended not only on the form in which it was supplied but also on the stage of growth at which it was given. A mixture of ammonium sulphate and potassium nitrate formed a better source of nitrogen to the rice plant than any one of them singly. Assimilation of nitrogen, phosphate and potash is fairly complete by the time flowers appear. The rice plant absorbs both ammoniacal nitrogen and nitrate nitrogen equally efficiently at low nitrogen supply; under moderate and high nitrogen supply, however, the plant utilizes ammoniacal nitrogen more efficiently than nitrate nitrogen up to the vegetative stage only, after which period, there is a definite preference for nitrate nitrogen (De Geus, 26; Nagai, 545; Dastur *et al.*, *Indian J. agric. Sci.*, 1933, 3, 157, 963; 1934, 4, 803; Sen, *Bull. agric. Res. Inst. Pusa*, No. 65, 1916).

Studies in U.S.A. are said to show that the phosphorus and nitrogen applied are both utilized more efficiently by rice under flooded soil conditions. Numerous experiments on nitrogen changes and the form in which readily available nitrogen is present in the waterlogged soil are reported from various countries. Ammoniacal nitrogen is found to be the predominant form of mineralized nitrogen present in the rice soil. Chemical changes consequent on water-logging are responsible for denitrification of nitrate nitrogen applied as fertilizer, or formed as a product of oxidation of ammoniacal nitrogen in the surface oxidized layer of soil, while ammoniacal nitrogen is considered stable under these conditions in the sub-surface zone of rice soil. Application in 2 or 3 split doses has yielded more favourable results and a

relatively higher availability of nitrogen is obtained with top dressed nitrogen at ear initiation stage as compared to basic application [Shapiro, *Soil Sci.*, 1957, 85, 190; De & Digar, *J. agric. Sci.*, 1954, 44, 129; 1955, 45, 280; Abichandani & Patnaik, *Int. Rice Comm. News Lett.*, 1959, 8(2), 16; Nagai, 549-51].

Besides ammonium sulphate, other fertilizers whose responses are reported not to differ significantly from those for ammonium sulphate are, ammonium nitrate, ammonium chloride, and ammonium sulphate-nitrate. Anhydrous ammonia injected into the soil has also proved as efficient as ammonium sulphate. Of the other chemical fertilizers tried, urea and calcium cyanamide are said to have proved much less efficient. But contrary to results obtained at experiment stations, the average response to urea in demonstration trials in cultivators' fields is reported to be the same as for ammonium sulphate (Sethi *et al.*, loc. cit.; Govindarajan & Rao, *J. Indian Soc. Soil Sci.*, 1957, 5, 133).

Experiments are said to have shown that with application of ammonium sulphate under ill drained conditions, toxic products like hydrogen sulphide and other respiratory inhibitors are formed and tiller formation and grain yield may be lowered by 10-20% (Desai & Rao, *J. Indian Soc. Soil Sci.*, 1957, 5, 155).

Concerning the optimum amount of nitrogen to be supplied as ammonium sulphate, it is said that with an application of 22-44 kg. of nitrogen per hectare the response varies from 330 to 770 kg. of grain in different centres, though in Bihar the responses vary from 440 to over 2,220 kg. per hectare (Verma, *Indian J. Agron.*, 1960, 5, 89).

The best method of applying nitrogenous fertilizers is to mix the fertilizer with 6-10 times its volume of earth and make it into small pellets and thrust 5-10 cm. deep into soil by hand at the time of weeding or after interculturing. It is stated that nitrogen applied in this manner is equivalent to double its quantity applied in the surface in the customary manner since loss of nitrogen by denitrification by the oxidation-reduction layer of the soil is prevented (Subbiah Pillai, 77; De Geus, 33).

Amongst the cultivated rices, the two groups Indica and Japonica exhibit a differential efficiency of nitrogen utilization. While Japonica rices stand a high level of manuring, Indica rices do well at a comparatively low level of nitrogen supply. Investigations carried on in Japan as well as at Central Rice Research Institute, Cuttack, on the differential



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FIG. 63—DEEP PLACEMENT OF FERTILIZER PELLETS

response of Indica and Japonica rices under tropical conditions have shown that after the vegetative stage the Indica rices are not able to utilize nitrogen as efficiently as the Japonica rices [Yamada & Noboru, *Int. Rice Comm. News Lett.*, 1959, **8**(4), 14].

Calculating the profits by fertilization at the present rates for ammonium sulphate and paddy, the optimum doses lie between 33 and 44 kg. of nitrogen per hectare, the average response to 33 kg. of nitrogen per hectare being 650 kg., with the response varying according to soil types. The additional response to 33 kg. of phosphate per hectare over nitrogen varied very widely, and the average was 253 kg. per hectare. The above optimum dose is based on the existing Indica varieties. There is no doubt that the optimum dose of nitrogen may be higher for new varieties with stronger straw and greater response to fertilization (Chavan *et al.*, *Indian J. Agron.*, 1957, **2**, 95; Desai *et al.*, *Andhra agric. J.*, 1957, **4**, 257).

Combinations of organic and inorganic nitrogenous manures always give better responses than the control, but not better than either of the components alone on the same nitrogen basis. However, at lower doses, below 44–50 kg. of nitrogen per hectare, combinations are better than ammonium sulphate alone. Such combinations either with green manure or cattle dung are more economical to the farmer, besides supplying the much needed organic matter. Experimental data available in Bengal, Orissa and

Madras show that no harmful results have arisen by continued application of ammonium sulphate without any organic matter. However, there is still a need for detailed and long range investigations in the different soil types of India, particularly in acid soils with a lower status of lime (Sethi *et al.*, loc. cit.; Digar, *J. agric. Sci.*, 1958, **50**, 219).

In South-East Asia and other countries, rice has been cultivated for centuries practically without the application of manures and fertilizers. Considerable discussion has taken place regarding the source of nitrogen in such areas since yields, though low, have not fallen off very much. One explanation is that rain water brings down some nitrogen with it as ammonia and the quantity so supplied by rain water varies between 2 and 17 kg./ha. per annum in different places depending on the intensity of rainfall and atmospheric disturbances like lightning. Secondly, nitrogen may be brought by irrigation water as soluble nitrogenous compounds, chiefly nitrates. A third source of supply of nitrogen is through micro-organisms like *Azotobacter* and by algal growths which are usually found in all paddy soils. Confirmation of their beneficial effect in fixing nitrogen, particularly in the case of algae, has been made available by recent experiments with inoculation of blue green algae [Nagai, 535–41; Grist, 186, 197; Susuma *et al.*, *Soil & Pl. Fd.*, 1959, **5**(1), 36; Uppal *et al.*, *Indian J. agric. Sci.*, 1939, **9**, 689; De & Sulaiman, *ibid.*, 1950, **20**, 327; *Soil Sci.*, 1950, **70**, 137; De & Datta-Biswas, *Indian J. agric. Sci.*, 1952, **22**, 375; De & Mandal, *Soil Sci.*, 1956, **81**, 453; Singh, R.N., 61–82; Misro, *Rice News Teller*, 1960, **8**(1), 8; Relwani, *Curr. Sci.*, 1963, **32**, 417; Relwani & Subramanyan, *ibid.*, 1963, **32**, 441].

PHOSPHATE

Information on uptake of phosphate by the rice crop is rather meagre. Investigations appear to indicate that the alluvial soils do not need any phosphate. In certain areas of Madhya Pradesh, Bihar and Andhra Pradesh, however, phosphate is found to be the limiting factor, there being a significant response to nitrogen only with addition of phosphate, with better results obtained when the phosphate and nitrogen were given in equal quantities. Due to the greater mobility of soil phosphate in waterlogged soils, there is a marked increase in the available phosphate and this is considered to be one of the causes of low response to applied phosphates. Trials are said to indicate generally that superphosphate and bone meal are better than the insoluble rock phosphates.

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Where facilities for growing a green manure crop exist, applying the phosphate to the green manure crop, which is later turned into the soil, is said to be a better practice. But where the soil is rich in phosphate, it is said to be advantageous to apply the phosphate to the rice crop direct than to the green manure crop (Sethi *et al.*, loc. cit.; Rao & Rao, *J. Indian Soc. Soil Sci.*, 1957, 5, 219; Digar & Mandal, *Indian J. Agron.*, 1957, 2, 81; De Geus, 80).

Trials conducted in Madras are said to have shown that soaking the seed in 10 or 20% tribasic potassium phosphate solution prior to sowing ensured a return by way of increased yield, that was 4–6 times the cost of treatment (Sethi *et al.*, loc. cit.; Narayanan *et al.*, *Madras agric. J.*, 1958, 45, 255).

Fertilizer trials carried out in cultivators' fields have shown (Table 11) that responses to nitrogen (33 kg./ha. N as ammonium sulphate) are said to be high in all places varying from 365 to 950 kg./ha. The response to phosphate (33 kg./ha. P as superphosphate) is much more variable, as low as 98 kg. in one State to as much as 530 kg. in another State. The

examination of the results on the basis of soil type shows that the response to nitrogen is highest in red and gravelly soils and grey and brown soils. Similarly the response to phosphate over nitrogen is more definite; it is low in coastal alluvium, alluvium and laterite soils, but high in medium black and red and gravelly soils. These trials indicate that the responses to nitrogen and phosphate obtained in the cultivators' fields are much higher than what were obtained at experimental stations, and that the response to phosphate is much more widespread than was expected. The soils tested so far also confirm the widespread nature of phosphate deficiency. In a study of utilization of phosphate fertilizer by paddy plants, maximum uptake was found to occur when the fertilizer was applied at the ground surface [*Indian Fmg. N.S.*, 1963–64, 13(5), 24].

POTASH

In deltaic alluvial soils the potash content is fairly high. Though considerable amount of potassium is removed by the rice crop through the straw, deficiency of potassium is not very common as soils in the rice growing areas are generally well supplied with potash. But it is possible that with intensive cropping using nitrogen and phosphate manures, the potash supply of the soil may get depleted. All areas in Bihar are reported to have shown some response to potash over nitrogen and phosphate and this was particularly noticeable in old leached sandy soils. In trials conducted in different States the average response for 44 kg. K₂O per hectare as muriate of potash over similar amounts of nitrogen and phosphate was 273 kg. per hectare. It is also reported that the application of potash is profitable in most places of South India. Investigations conducted in Japan are said to show that deficiency of potassium is a predisposing factor in the development of sesame leaf spot; its application helps to reduce infection by stem rot, bacterial blight and *Cercospora* leaf spot (Raheja *et al.*, *J. Indian Soc. Soil Sci.*, 1958, 6, 29; Sircar & Dutta, *Indian J. agric. Sci.*, 1957, 27, 1).

LIME

Rice, which is mostly grown on the acid soils of the tropics and sub-tropics, has not shown consistent response to the application of lime and the proper function of the latter in rice nutrition has not been completely investigated. Many of the rice soils of India have a high reserve of calcium and may not require liming as a rule. Application of lime in paddy

TABLE II—RESPONSE TO NITROGEN AND PHOSPHORUS IN DIFFERENT STATES AND IN DIFFERENT SOIL TYPES

STATES	Control yield kg./ha.	Additional yield in response to	
		Nitrogen 33 kg./ha.	Phosphate 33 kg./ha.
Madras	2,335	451	237
Mysore	2,853	835	388
Coorg	3,750	463	198
Kerala	2,482	569	233
Andhra Pradesh	2,681	438	98
Orissa	1,902	376	348
Punjab	2,378	955	530
Madhya Pradesh	1,820	623	413
<i>SOIL TYPES</i>			
Red loam	2,693	474	277
Medium black	2,699	655	623
Shallow black	2,285	783	469
Grey & brown soils of Indo-Gangetic basin	2,379	955	..
Red & gravelly soils	1,981	1,010	652
Red & yellow soils	2,003	652	435
Coastal alluvium	2,567	469	132
Laterite	3,514	675	213
Mixed red & black soils	3,165	509	343
Alluvium	3,133	600	180

fields tends to increase leaching losses of nutrients. Too much lime makes the straw weak and imparts to the grain an inferior taste and lustre and makes it more brittle, besides affecting its nitrogen composition as the lime treated grain is poorer in protein. Its use may be warranted only in laterite soils of Assam, Maharashtra and Kerala States.

Liming is reported to mineralize nitrogen by providing the optimum pH for the micro-organisms in the soil and thus favours the decay of organic matter and accelerates the formation of ammonia. Lime with phosphate has given better results than phosphate alone (Abichandani & Patnaik, *Int. Rice Comm. News Lett.*, 1955, 13, 11).

The role of calcium seems also to be associated with that of magnesium. Calcium/magnesium ratio seems to have an effect on the yield of rice. Where this ratio is near 1:1, crop response to other fertilizers is said to be good, but where calcium is very much less than magnesium not only crop response is poor but deficiency symptoms like white tip are said to occur.

MICRO-NUTRIENTS

Most of the information on the exact role of trace elements of rice nutrition has come from Japan, the Philippines and Burma and some work has been reported recently from Ceylon, India and Malaya [Sethi *et al.*, loc. cit. ; Abichandani, *Rice News Teller*, 1955, 3(2), 88 ; Patnaik, *Bull. nat. Inst. Sci. India*, No. 8, 1955, 65].

Iron and manganese are considered important and lack of these brings about chlorotic symptoms in the plant. There seems to be an optimum ratio between these two elements. In India, manganese toxicity is reported to be prevalent in some new areas of black soil brought under irrigation and rice cultivation. In Ceylon, correction for manganese toxicity has been recommended by drying the soil, by using leguminous green manures and applying calcium carbonate. There is abundant evidence that the iron requirement of rice is much higher than that of most crop plants and that submergence increases the availability of iron. There is also evidence that an excess of reduced substances, specially iron and manganese, may be toxic to rice (Rao & Rao, *Andhra agric. J.*, 1958, 5, 130 ; Baba, *Trop. Agriculturist*, 1958, 114, 231).

Sulphur deficiency in rice plant is also reported to bring about chlorosis, reduction of height, narrowing of leaves and failure to reach maturity. The absorption of iron and manganese also seems to be correlated

with sulphur intake. Boron, zinc and copper deficiencies have been investigated in water culture studies (Saran, *Curr. Sci.*, 1949, 18, 378 ; Patnaik, loc. cit. ; Sethi *et al.*, loc. cit.).

The supply of soluble silica is considered by some to be an important factor governing the growth and yield of paddy under dry and flooded soil. Sodium silicate is said to increase the yield of grain and straw. Use of colloidal or soluble silica gave an increase of 30-40% in yield when 1,100-1,800 kg./ha. of basic slag was applied. Incidence of *Helminthosporium* disease is reported to be related to silica content in Japan. With increased silica uptake, rice plant is said to become more resistant to leaf spot and blast diseases, perhaps due to increased silicification of upper epidermal cell walls (Sreenivasan, *Proc. Indian Acad. Sci.*, 1936, 3B, 258, 302 ; Volk *et al.*, *Phytopathology*, 1958, 48, 179).

Beneficial effects (10-28% increased yields) due to use of copper sulphate, magnesium sulphate and zinc sulphate, alone or in combination, have been recorded in Madras, Mysore, Maharashtra and Orissa. Zinc sulphate and borax applied individually and in combination have also given higher yields of both grain and straw (Patnaik, loc. cit.).

IRRIGATION

Though rice is a water loving plant, it is advantageous to regulate the supply of water in the nursery and later in the field by giving the optimum requirements at suitable intervals. In the case of wet seed bed, where sprouted seed is sown, the sowing has to be done in standing water 5-8 cm. deep. The water is later drained off completely till the seedlings emerge clearly. The beds are then irrigated and drained frequently until the seedlings have grown 5-8 cm. tall when water to a depth of 1.0-2.5 cm. can be retained permanently. A slightly raised seed bed with channels all round is recommended in the Japanese method of rice cultivation, as it facilitates watering and draining, which are conducive to rapid growth of seedlings.

Transplantation is usually done in 1.0-2.5 cm. of standing water and excess water is drawn off immediately afterwards to help plants strike root. Water is allowed to stand in the field later when the plants establish themselves, the level being gradually raised up to 20-23 cm. unless there is uncertainty in the supply of water. If water facilities permit, a slow but continuous flow is preferred so as to get the benefit of the silt carried by the irrigation water and also to

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aerate the roots of plants. In general, it is recognized that once the flooding of the fields has commenced, the field should not be allowed to dry out until the grain starts ripening. Water is drawn off or reduced considerably for a few days for weeding and for application of fertilizers, but the maximum depth possible is maintained at the time of flowering and grain setting, after which it is gradually reduced and completely drawn off when the grain is half ripe. While the above is the general practice wherever lowland rice is grown, critical experimental data are necessary to show whether this is the most desirable practice or whether it can be improved. There is great necessity to investigate the water requirements in relation to the development of the plant and final yield, as there is a general feeling that too much of water is wasted in tropical areas, and there should be scope for economy in its use so as to allow more areas to be grown with the available supply of water.

India has the largest mileage of irrigation canals. The irrigation facilities provided range from construction of dams across rivers and reservoirs with large catchment areas for impounding rain water, to wells sunk to tap sub-soil water. In the latter case, water is lifted mainly by human or animal power; electricity is also employed where available.

The water requirement of rice has been determined in many countries including India. It varies from as low as 30 acre inches for a five months' crop in Japan to as much as 100 acre inches in Italy for the same five months' crop. In India, the average figures for many centres are 40 inches for a crop taking 3-4 months and 70 inches for a crop taking 6 months. This quantity also includes the effective rainfall that may have been received during the growing season. About 30% of the water is utilized for the initial preparation of the land, 57% for the growing stage from transplanting to heading and another 12% for the ripening stage.

Experiments to determine the amount of water needed to irrigate different areas in South India have indicated that the duty of water varies in general with the type of soil, season of cropping, whether it is a long or short duration crop and the amount of rainfall the crop receives during the cropping season. Table 12 summarizes the results of trials in selected areas in South India. It will be seen that the duty is generally higher for heavier than for lighter soils and the duty for short season crop is not higher than for longer monsoon crop. These figures, however, give no information on the amount of water consumed by the crop, allowing for losses by evaporation and percolation. In Java, regular investigations have been

TABLE 12—DUTY OF WATER FOR RICE IN DIFFERENT REGIONS IN SOUTH INDIA

Agricultural research station	Region	Soil conditions	Cropping season	Av. duty acres for 1 cusec
Aduthurai	Cauvery (old delta)	Heavy alluvium	July Oct. 1st crop	68
	do.	do.	Aug.-Jan. main crop	76
	do.	do.	Oct.-Feb. 2nd crop	80
Pattukottai	Cauvery (new delta)	Sandy loam	July-Oct. 1st crop	37
	do.	do.	Aug.-Jan. main crop	47
	do.	do.	Oct.-Feb. 2nd crop	67
Coimbatore	Canal irrigation supplemented by wells	Black soil of a lighter type	Aug.-Feb.	51
Lower Bhavani	New project area	Light gravelly soil	Aug.-Feb.	40
Siruguppa	Tungabhadra project area	Heavy black soil	July-Dec.	60
Bangalore	Irrigation from tanks	Black clay loam	July-Dec.	70
	do.	do.	Feb.-June	70
Maruturu	Codavari & Krishna river deltas	Heavy black clay	June-Dec. 1st crop	81
	do.	do.	Feb.-Mar. 2nd crop	54

carried out on the water requirements of rice, and different duties have been prescribed on the basis of soil types and different stages of the growing crop.

Experimental studies on transpiration have shown that in a heavy soil, growth and yield were affected if the soil was kept submerged, while in lighter soils submersion and periodical flooding suited normal growth. Investigations regarding the necessity or otherwise for continued submersion of the soil after the transplanted crop has established itself are said to show that in heavy soils of India, provided the weeds were under control, standing water was not necessary; in fact, some types did very much better under field capacity condition than under submerged condition. Flooding the field for 3 weeks or more after transplanting and dewatering it later were found beneficial.

Experiments conducted on duty of water at several centres in Madras, Andhra Pradesh, Uttar Pradesh, and West Bengal to find out the effect of varying the quantities and intervals between irrigations on yield are said to show that: (1) by maintaining a constant depth of water not less than 5.0–7.5 cm. with a frequent change of water the production was the highest; (2) giving small quantities of water at frequent intervals was more beneficial than a large quantity given at less frequent intervals; and (3) any interval between two irrigations longer than 5 to 6 days was definitely harmful to the crop. A rainfed crop was found to benefit considerably by an occasional irrigation (Subbiah Pillai, 73).

Regarding optimum depth of water necessary, investigations in Indonesia and Japan have shown that a shallow depth of 7.5 cm. would be best for constant maintenance. However, existing arrangements in many of the canal irrigated areas in India make it difficult to put into practice the experimental findings that the rice crop prefers smaller but more frequent supplies of water; this is possible in parts of Madras and Andhra Pradesh where rice is grown under lift irrigation.

From the physiological viewpoint, it has been shown that wet rice grows best under saturated or nearly saturated condition for a greater part of life and soil submergence will be necessary at least soon after transplanting and again when the young ears are forming. Under such anaerobic conditions resulting from submergence, the leaching action is less and the ammonia is retained in the soil as ionic ammonium. Further submergence of the soil brings about an increase in pH , an increase in specific conductance,

and a decrease in redox potential. It also brings about the reduction of iron and manganese and an increase in solubility of silica. Lastly it helps in fixation of nitrogen by algae.

IMPROVED IMPLEMENTS AND MECHANIZATION

In India rice is mostly cultivated in small individual holdings and complete mechanization is neither possible nor desirable. Intensification of rice growing is, however, important and use of improved tools and small machines is said to have the largest scope. Some of the improved implements suggested for use are: iron mould board plough in place of the ordinary wooden plough, two types of puddlers, a levelling board, a green manure trampler, a mechanical seed drill, a special hand-operated rotary hoe for weeding and a pedal thresher. Use of special types of tractor and a Rotavator for puddling has also been recommended (Subbiah Pillai, 10, 94–97; Ghose *et al.*, 59–66).

GROWTH AND MATURATION

Tillering Tillering begins two weeks after planting and the depth at which it begins is regulated by the light perception of the plant and by the depth at which the grain is sown or the rice seedling transplanted. Though much influenced by environmental conditions, tillering is still a varietal character. Effective tillering, i.e. the percentage of tillers producing ears, is again a varietal character and may vary from 4.5 to 70%. Strains which start tillering early and have an extended tillering phase give high yields. The depth of standing water should be as low as possible during the active tillering phase. The optimum temperature for tillering is between 32° and 34° . The height of the individual tiller depends mainly on its vigour and environment, and not on its chronology. Fertilization at the maximum tillering phase has been found to increase the weight of the panicles, and draining the water at this stage or even slightly earlier helps in better root development and diversion of the absorbed nutrient to the panicle, rather than to vegetative growth (Ramiah & Rao, 17, 186).

Root—The development of the root system varies according to the maturation period of the rice types; it is less developed in those of a short maturation period than in those of a long maturation period; it is more delicate in those producing fine rice than in those with coarse grain. There is also a positive correlation between the number of tillers and number of roots per plant. It has been observed that typical



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FIG. 64—SOME IMPROVED IMPLEMENTS FOR RICE CULTIVATION—A WET PUDDLER (RIGHT); A GREEN MANURE TRAMPLER (MIDDLE); AND A BURMESE SATOON (LEFT)

wet rice develops a more extensive root system in puddled soils than when grown under upland conditions, whereas the typical upland rice behaves in the reverse way. Even in wet rice, root development is at its maximum in clay soil (Parr, *Agric. J. India*, 1912, 7, 73, 368 : Smith, *Int. Rev. Agric.*, 1931, 22, 169 T).

Investigations conducted in U.S.S.R. on the anatomy of the roots of rice plants are said to show that the rice plant is not a typical inhabitant of marshy conditions. The development of a normal layer of epidermis in the zone of differentiation, its retention when the plant is grown in well aerated soil and the development of root hairs in the zone of absorption under dry conditions, are said to support this view. It is, therefore, postulated that the development and maintenance of a stable soil structure is important for obtaining large harvests when rice is grown as a dry crop. Depth of root system varies with cultural practices, broadcast rice developing a deeper, but poorly developed root system, whereas transplanted rice has shallow but well developed root

system. In all rices, irrespective of their maturation period, the roots start dying when the grain has ripened and there is no further root activity even if moisture is present in the soil. Root development reaches its maximum when the soil is fertilized with bulky organic manures such as green manure. Nitrogenous fertilizers, such as ammonium sulphate, also promote root development. The nutrient absorbed by the roots increases with the growth of the roots, and ceases with grain development [Smith, loc. cit. : Rajagopalan, *Madras agric. J.*, 1958, 45, 29 ; Velichko, *Rice News Teller*, 1961, 9(2), 19].

Shoot—The height of the stem depends upon the number of the internodes and is a distinct varietal character. Japonica rices all have short stem (1-1.5 m.), but there is considerable variation in height among Indica rices (1-3 m.). In the floating rices the stem may grow even up to 5-6 m. at the maximum water depth. The stem is cylindrical and hollow except at the nodes and varies in thickness from 6 to 15 mm. Non-lodging and flood resistant types are well equipped with sclerenchymatous tissue

and have more numerous fibro-vascular bundles as compared to lodging types. The air cavities are always conspicuous in the floating rices and a positive correlation has been observed between the percentage area of air cavities in stem sections and resistance to floods (Ramiah & Rao, 18, 187, 196).

Leaf—The length and width of leaf may vary between 30 and 50 cm. and 1.2 and 2.5 mm. respectively. Rices with large leaf blades generally also have large or bold grains. The depth of green colour in the blade varies and a large number of chlorophyll deficient types occur as mutations (Ramiah & Rao, 123, 125).

Panicle—A rapid growth in height of the tiller in the later stages foretells the onset of the reproductive phase. A difference of two to three weeks in the ages of tillers gets reduced to a few days only in earhead formation, since the ear formation is independent of the tillering phase. The period when ear formation commences is said to have a practical significance in adjusting the fertilizing practices. It takes about 5 weeks for the ear primordium to develop into a full ear and come out of the enclosing leaf sheath. Two days after the panicle emerges out of the leaf sheath, the spikelets start opening. A plant takes five to seven days to complete heading, irrespective of the number of tillers.

Anthesis—Flowering and anthesis begin on the same day or the day after the heading of the panicle. The opening of the spikelet and anthesis is dependent to a large extent upon light, temperature and humidity. The most active flowering takes place in the forenoon when the temperature is 27–30° and humidity 70–80%. Dehiscence of the anthers may take place just prior to the opening or, as is most common, at the moment of emergence. Consequently, self-pollination followed by self-fertilization is the rule, but anthers failing to dehisce at the time of spikelet opening may provide an opportunity for cross-fertilization. Wind and insects are the chief agents and a natural crossing of 0.1–4.0% has been recorded in different countries. Environmental conditions affect the percentage of natural crossing and varieties also differ materially in extent of natural crossing. In India, it has been observed that where wild rice (*O. rufipogon*) grows in the proximity of cultivated rice, the percentage of natural crossing can be as high as 8–15%. Natural crossing to the extent of even 23% has been recorded in Java. Fertilization is also possible without the spikelet opening, and this happens in a cleistogamous strain

[Ramiah & Rao, 19; Hector, *Mem. Dep. Agric. India, Bot.*, 1931, 6, 1; Kadam & Patel, *Indian J. agric. Sci.*, 1933, 3, 577; *Poona agric. Coll. Mag.*, 1934, 25, 1; Butany, *Rice News Teller*, 1957, 5(3), 18; Butany & Gangadharan, *ibid.*, 1960, 8(3), 6; Bhide, *Agric. J. India*, 1914, 9, 211].

Grain development—The morphological formation of the embryo is complete by about the tenth day after anthesis. *In vitro* culture of excised embryos of rice has been tried successfully and is considered to be of potential use in raising interspecific hybrids which may otherwise be non-viable. In rice varieties which mature within 4 months, the grain is fully ripe in 25 days after fertilization, whereas it takes about 35 to 40 days in late maturing varieties [Butany, *Rice News Teller*, 1958, 6(3), 10].

Maturation—Among cultivated rices the maturation period, or the interval of time between the sowing of the seed and the ripening of the resultant plant, varies very considerably from 85 to 240 days among Indica rices and from 100 to 170 days among Japonica rices. The total maturation period of transplanted rice can be divided into three phases: (i) the seed-bed stage, (ii) the vegetative stage, and (iii) the reproductive stage. Maximum variation in maturation period is said to occur in the vegetative phase only, and any change in climate, soil or cultural practice brings about an alteration in this phase.

Agricultural conditions that affect the maturation period are the fertility of the soil and the method of planting the crop either by direct sowing or transplanting and, in the latter case, the spacing allowed between plants. The difference in maturation period brought about by the above factors is, however, seldom significant, being about a week to ten days only, and these conditions are also controllable. Climatic conditions that affect heading time are temperature, day length, humidity, rainfall, altitude, etc. Of these the day length and temperature are considered the most important. In rice, reduction in day length accelerates the differentiation of young ears and heading, and a long day retards them. Similarly, high temperature accelerates and low temperature retards heading. An indirect evidence on the action of temperature is afforded by the fact that rice varieties take a longer time to mature when grown in higher altitudes. The change in maturation period to a longer growing period, however, is often associated with higher productivity.

The effect of differing day length and temperature is not the same in all rices and there exists a group

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of varieties where alteration of day length does not make any large change in the maturation period. According as the alteration in the day length has or has no effect on the maturation period, rices are grouped into sensitive and insensitive types. Among sensitive types, the degree of sensitivity may again vary. In Indonesia and the U.S.A., they are grouped into sensitive and less sensitive types, there being no insensitive types.

The sensitive and insensitive types correspond to season bound and period bound types. The period bound types are those which, irrespective of when they are sown or planted, take more or less the same period to come to harvest, while the season bound types come to harvest at a particular season of the year though with slight variations, irrespective of the time of sowing or planting. Most of the early maturing types (90–110 days), that are planted in summer or spring belong to period bound group; the mid-season and late types, generally sown in July–September belong to season bound group (Ramiah & Rao, 1979).

Every rice variety, irrespective of day length and temperature, has to put on a certain amount of vegetative development, variable in different types, before differentiation of ear can take place. Thus, the maturation period depends upon three factors, basic vegetative growth, sensitivity to day length and sensitivity to temperature. It is considered that by determining the basic vegetative growth and its sensitivity to day length and temperature, the suitability of a rice type for any particular region can be inferred.

A number of investigations on the aspect of photoperiodism in rice have been conducted in India. It has been found that *Bhasmanik*, a sensitive type of Bengal, produced a significant increase in the number of ear-bearing tillers and also yield, with an earliness of 20 days when subjected to a continuous short day (8 hours) until ear emergence. Photoperiods slightly longer or shorter than the natural day are reported to be conducive to greater seed production. It was established that the degree of reaction to day length is a varietal character, and that the effect is of a quantitative nature, the degree of earliness induced increasing with the duration of the treatment. A case of remarkable reduction in flowering duration from 133 to 47 days by short day treatment in winter rice *Rupsail* has been recorded (Sircar & Ghose, *Nature, Lond.*, 1947, 159, 605).

Though it was believed that early maturing rices

are generally insensitive to day length, work in India and Ceylon has shown that even these rices may show some sensitivity [Misra, *Agron. J.*, 1955, 47(9), 393; Roy & Subramanyam, *J. Indian bot. Soc.*, 1955, 34, 455].

Results in Ceylon have indicated that high yield cannot be combined with insensitivity to photoperiod; results available in India and Indonesia, however, do not support this finding. At the Aduthurai Research Station, Madras, a hybrid strain, *Adt-20*, with satisfactory yields of grain (3,300 kg./ha.) has been developed by crossing *Adt-4*, an early maturing insensitive strain, with *Adt-2*, a sensitive and late maturing strain. The hybrid strain is early and insensitive with yields better than *Adt-4* and comparable to *Adt-2*.

In South-East Asia, agricultural conditions, especially water supply, govern the use of rices of particular maturation periods. Available results on rice breeding show that by proper choice of parents, progenies of any required maturation period can be obtained.

Sensitivity to photoperiod is a genetic character controlled by genes. Investigations in progress at the Central Rice Research Institute, Cuttack, would appear to indicate that there is an almost parallel variation with regard to this character in both cultivated and wild rices. The evolution of cultivated rices with varying degrees of sensitivity to photoperiod must have taken place by changes in the genes and systems of modifiers to make them suitable for particular day lengths under natural conditions (Ghose & Sastry, *Euphytica*, 1954, 3, 221).

DISEASES AND PESTS DISEASES

The list of fungi causing diseases in rice is long and only those which at various times have caused appreciable losses to the crop are dealt with here. These diseases occur more or less constantly causing what would appear to be insignificant or occasional losses to individual growers, though making a substantial total in the aggregate in the country; under favourable conditions, some diseases occur as epiphytotes and cause considerable loss. It is stated that nearly 80% of crop was lost due to *Piricularia* in 1920 in South India and one of the major causes of famine in Bengal in 1942 was due to an epidemic caused by *Helminthosporium* (Ghose et al., 67, 418; *Agric. Handb. U.S. Dep. Agric.*, No. 165, 1960, 193; Padwick, 133–89; Grist, 265).

Blast disease—This is caused by *Piricularia oryzae* Cav. It is the most important and destructive disease of rice which is prevalent over all the rice regions of both hemispheres. The disease can affect the plant at all stages of growth, in the seedlings (seedling blight), in the active growing phase (leaf blast), and at the stage when heads are developing (neck rot). The last is the most serious, and the entire crop may be lost. In India, the leaf blast and neck rot are common and only very rarely does the seedling blight occur. The leaf infection is the most common wherever the disease occurs (Padwick, 4; Krishnaswamy *et al.*, *Res. Ser., Indian Coun. agric. Res.*, No. 21, 1959).

Attempts have been made mainly in Japan and in India to determine the losses due to diseases. In Japan the loss due to *Piricularia* amounted to one-third of the total loss brought about by all the adverse factors, pest and disease incidence, unusual weather conditions, etc. At the Central Rice Research Institute, Cuttack, an experimental determination of the loss due to neck infection of *Piricularia* showed that for every 1% increase in neck infection the loss in yield amounted to 0.95% or 20 kg. of paddy per hectare (Ghose *et al.*, 231).

The development of the disease requires certain optimum conditions of temperature and humidity. Temperature of 24–27° and humidity of over 90% are considered conditions favourable to the disease, and if the atmospheric conditions are favourable, the multiplication of the fungus is very rapid (Suryanarayanan, *Proc. nat. Inst. Sci. India*, 1959, **24B**, 285).

The disease is considered largely air-borne, and, therefore, seed treatment is not of much help. Leaf blast can be prevented by spraying Bordeaux mixture repeatedly in the seed bed. Several copper fungicides are also effective and better results are said to be obtained by using low volume nozzles to the sprayer. The neck rot stage of the disease is difficult to control chemically. Growing of blast resistant types is said to be a sure way of reducing losses due to blast (Padwick, 17; Ghose *et al.*, 235; Padmanabhan *et al.*, *Indian Phytopath.*, 1956, **9**, 15; Padmanabhan, *Proc. Indian Acad. Sci.*, 1959, **49B**, 349).

Breeding for blast resistance has been pursued for nearly a quarter of a century in this country and also in Japan. A series of really resistant strains have been obtained, the most important resistant parent in crosses being *Co-4*. There have also been a few other strains as resistant as *Co-4*. There is no immunity to blast in rice but only fair to high resistance. For example, in the highly resistant strain *Co-4*, the

fungus just penetrates the tissue but the affected spots do not develop into lesions. Out of 14 resistant progenies developed in this hybridization programme, 4 have already been released for general cultivation, and the rest are undergoing trials. Nitrogen beyond 33–44 kg./ha. increases blast in susceptible strains, but doses up to 132 kg. nitrogen per hectare are reported not to cause any greater incidence in the new strains *Co-25* and *Co-29*. A large number of genetic types are being tested for resistance at Cuttack both for *Piricularia* and *Helminthosporium* (Ramiah & Rao, 216–20; Ghose *et al.*, 232–35).

The following steps are advocated for control of this disease: (1) growing resistant types; (2) avoiding excessive nitrogenous manuring; (3) adjusting planting dates (by planting early in some localities); and (4) spraying the crop 3–4 times with copper fungicides (Parthasarathy, *Farm Bull., Indian Coun. agric. Res.*, No. 1, 1954; Ghose *et al.*, 68, 234).

It is reported that in many cases types found resistant to blast in some areas cease to be resistant when introduced to a new area. Environmental conditions may play an important part in determining resistance and it is possible that there may be different physiological races (so far 12 races have been identified) of the fungus showing marked differences in virulence (Padwick, 14; Ghose *et al.*, 234).

A large number of collateral hosts of the fungus have been recorded in India, and these are *Panicum repens*, *Digitaria marginata*, *Leersia hexandra* and *Dinebra retroflexa*. Of these the first one is by far the most common and mainly responsible for the carrying of the disease from one season to another (Ghose *et al.*, 231).

Some work has been done in Japan and in India concerning the nature of blast resistance in rice. In Japan, resistance to blast was associated with increased thickness of the outer wall of the leaves and of the silicified cells of the outermost epidermal layer; actual application of soluble silica under flooded conditions increased resistance to blast. Fewer silicified epidermal cells were found in unit area in susceptible types in India, as compared to resistant types. Application of large doses of nitrogenous fertilizers or green manures is said to result in reduction of silicified cells in the epidermis. In Japan a close correlation has been found between predisposition to blast and amount of amino and amide nitrogen in the tissue (Adyanthaya & Rangaswamy, *Madras*

agric. J., 1952, **39**, 198; Suryanarayanan, *Curr. Sci.*, 1958, **27**, 447).

Investigations in Japan are said to show that it is possible to forewarn about a general outbreak of blast by observing carefully the development of the disease pattern in highly susceptible types earlier in the season. Similar work has been undertaken in this country also [Kawada, *Rice News Teller*, 1958, **6**(1), 35; Padmanabhan & Chandnani, *ibid.*, 1960, **8**(4), 8].

Brown Spot or Sesame Leaf Spot—This is caused by *Cochliobolus miyabeanus* (Ito & Kurabay.) Drechsler ex Dastur.=*Helminthosporium oryzae* Breda de Haan and is prevalent in all rice growing areas of both east and west. Damage to the crop occurs in the seedlings, growing plant and the grain in the panicle and may sometimes cause a loss of crop to the extent of 30–90%. Both seed and soil may serve as the source of infection. Seedlings raised from infected seed are subject to seedling blight or primary infection and can be somewhat controlled by seed treatment before sowing. In an area, where varieties of different maturation periods are cultivated, a badly attacked early maturing crop can be the source of infection for the later maturing crop. *Echinochloa colonum* and *Leersia hexandra* are reported to be collateral hosts of the fungus (Padwick, 1952, 21; Ghose *et al.*, 236–39; Chattopadhyaya & Chakraborty, *Nature, Lond.*, 1953, **172**, 550).

Owing to incomplete knowledge regarding the survival of the fungus and the source of infection, existing control measures are said to be inadequate. The optimum range of temperature for the primary infection is considered to be 16–24° and when temperatures are much higher there is no infection, but it occurs when sowing is done in cooler weather. Plants grown under dry conditions are said to be more susceptible, because such conditions bring about poor development and poor silicification of the cells of the outer walls. Studies conducted in Japan are said to show that a deficiency of potassium is one of the predisposing factors. Experiments on rice seedlings raised with four levels of nitrogen, viz. 105, 161, 217 and 329 p.p.m. and inoculated with the fungus are said to have shown very mild infection in the case of the middle two concentrations, but severe infection in the other plants which received low or excess of nitrogen, as the case may be. There is said to be a close association in the plant between resistance to root rot and resistance to *H. oryzae*. A considerable variation has been observed among varieties

with regard to their susceptibility. Out of nearly 500 varieties examined in India, a few have come out resistant, both under artificial infection tests and under conditions of natural infection in the field. Since many of these are established improved strains, they can be grown to the exclusion of other susceptible ones in areas to which they are found suitable. Beyond high resistance, no immunity has been observed. Investigations in Cuttack have shown that susceptibility of rice types to *H. oryzae* was reduced by soaking germinating seeds in cold water extracts of *H. oryzae* (Ono, *Jap. Pot. Symposium, International Pot. Inst.*, 1959; Chattopadhyay & Dickson, *Phytopathology*, 1960, **50**, 439; Padmanabhan *et al.*, *Indian Phytopath.*, 1953, **6**, 96; Ganguly & Padmanabhan, *ibid.*, 1959, **12**, 99; Ghose *et al.*, 238–39).

Narrow Brown Leaf Spot—This is caused by *Cercospora oryzae* Miyake. It causes lesions in leaf blades, leaf sheath, peduncle and the glumes. Growing of resistant types is the only known sure way of controlling the disease. Several physiological races of the fungus have been identified and types resistant to some or all of them have also been determined. No relationship has been observed between morphological characters like straw colour, endosperm consistency, etc., and disease resistance (Padwick, 34–39).

Stem Rot or Sclerotial disease—This is caused by *Leptosphaeria salvinii* Catt.=*Helminthosporium sigmaeum* Cav.=*Sclerotium oryzae* Catt. and is said to follow the attack of the rice plant by the leaf hopper, *Nilaparvata*. Due perhaps to a greater use of nitrogenous fertilizers in Japan, stem rot incidence is said to be increasing in severity in recent years. The fungus survives in the sclerotial stage, and the sclerotia from the old rice straw and stubble germinate readily in spring and are carried from field to field by irrigation water. No satisfactory measures of control are available except that of withholding standing water from the fields for a period prior to maturity. If used in conjunction with the practice of burning rice stubble and straw, it is likely to give good results. In Japan, some of the mercurial dusts, particularly Ceresan lime, are used to control the disease. Japonica rices are stated to be less susceptible than Indica rices and even amongst the latter, several are said to be highly resistant to this disease (Parthasarathy, *Farm Bull., Indian Coun. agric. Res.*, No. 1, 1954; Ghose *et al.*, 240–41).

Bakanae disease or Foot Rot—This is caused by

Gibberella fujikuroi (Saw.) Wollenw. and is common in India and in many countries of Asia. In South India, it sometimes causes serious loss to the crop particularly in the seed beds, and is considered next in importance to blast amongst the diseases. The characteristic symptom of the disease is the abnormal elongation and etiolation of the plant in the seed bed and later in the field. In the transplanted crop the affected plants grow thin and pale without tillering, and shoot up conspicuously above the level of other healthy plants and die finally. That the disease is bad in South India may be due to the fact that the temperature conditions at the time seed is sown are just about the optimum requirements of the fungus, about 35° , whereas in North India the temperatures are somewhat higher than 35° at the time the first crop is raised. For a similar reason, rice grown in winter is free from the disease while that grown in summer is affected in Ceylon (Thomas, *Madras agric. J.*, 1933, 21, 263; *Mem. Dep. Agric. Madras*, No. 36, 1954, 1121; Padwick, 74-84; Abeygunewardena & Peiris, *Trop. Agriculturist*, 1956, 112, 109).

The disease is mainly carried in the seed and there can also be infection of the seedling from the soil. Isolates of the fungus from different localities are said to exhibit various degrees of virulence. The fungus has also been isolated from jowar, *bajra* and sugarcane, and the isolates differ in their pathogenicity. No type has been found immune, but two types (*GEB-24* and *Ptb-7*) are said to be highly resistant. Since to a large extent the disease is seed borne, seed treatment has given a high measure of control. Among the fungicides tried, Ceresan and Agrosan GN (used at the rate of 1 kg. for 495 kg. of seed) have given the most satisfactory results. This disease which was once important is now rare in Japan, because 8.5% of all rice grown is from seed treated with organo-mercurial dips (Thomas, loc. cit.; Ramiah & Rao, 223; Ghose et al., 242-43; Rajagopalan, *Curr. Sci.*, 1961, 30, 149).

Some of the other diseases reported in India are, Stackburn disease caused by *Trichocomis padwickii* Ganguly, Bunt by *Neovossia horrida* (Tak.) Padwick et Azmatullah Khan, False Smut by *Ustilaginoidea virens* (Cke.) Tak., Ubhatta disease by *Ephelis oryzae* Syd., and Ufra, a serious disease caused by nematode, *Ditylenchus angustus* (Butler) Filipjev. Their occurrences are sporadic and damage caused by them is mostly negligible (Ghose et al., 244-47).

PESTS

Insects cause extensive damage to rice crop in the field and to grain during storage. About 85 species of insects are reported to have been recorded as pests on rice. Some are of negligible importance, but under favourable conditions even a minor pest may pose a serious threat. The worst amongst them are paddy bugs, stem borers, army worms and grasshoppers. Some of the more important pests are treated below [Israel et al., *Rice News Teller*, 1961, 9(2), 23; Ghose et al., 74-81, 248-57; Grist, 236-64].

Stem Borers - Stem borers are some of the most destructive pests of rice. Among the many species of borers causing damage, the one that causes the greatest damage is the yellow stem borer, *Schoenobius incertulas* (Walker). The borer attacks the young plant either in the nursery or in the field, and bores into the main stem killing it and producing a 'dead heart'. In the transplanted field, while the main shoot may be killed by the larva, new side tillers are produced, but many of the later tillers never produce ears. The period when relatively high humidity and low temperature prevail is said to be favourable for the multiplication of the stem borer. Many generations of borers are passed in a single rice season. The borer population is at its maximum at the second or third generation, and this may synchronize with the flowering period of the rice plant. The damage to the crop at this stage results in the characteristic 'white ears' where the spikelets remain white and papery without any grain formation [Ghose et al., 74, 248; Rao & Varatharajan, *Rice News Teller*, 1961, 9(1), 23].

The stem borer being an internal feeder, ordinary insecticidal control did not prove of much value previously. In India, the use of 5% BHC as dust or as 0.2% spray at the time moths are present in large numbers is said to considerably reduce the incidence of *Schoenobius*. However, its efficacy is limited and can be directed only against adult moths and the larvae wandering outside the leaves; it does not kill the concealed borer inside the stem or leaf sheath. Application of insecticidal formulations like Parathion, Endrin, BHC and Folidol has been reported as most effective (Ghose et al., 249; Abraham & Santhanaraman, *Madras agric. J.*, 1959, 46, 380).

As Parathion and Endrin are highly poisonous chemicals, they present serious hazards to users unless special precautions are taken. Their use in rice fields is likely to kill fish and frogs and it is this hazard that has prevented their trials in Malaya and Ceylon.

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The dusting or spraying has however to be done properly and at the proper time based on the life history of the insect.

Since the attack by the stem borers often starts in the nurseries, treating the crop in the seed bed before transplanting gives effective control of the pest. Dipping the uprooted seedlings in 0.08% solution of Folidol E. 605, before planting protects the plants against egg laying if a brood has emerged at the time of transplanting (Ghose *et al.*, 250).

There is no rice variety that is completely resistant to stem borers, but considerable variation is said to exist among rices with regard to borer incidence. Studies in Japan are said to indicate that a rice with a thick culm is more easily attacked than one with a thin culm and in investigations in Cuttack the rice which has shown the least incidence has thin culms. Wider spacing and greater availability of nitrogen may lead to an increase in stem borer infestation as under these conditions the plants have thicker and more succulent culms.

Resistance to stem borer is believed to be a genetic character on the basis of results available in Egypt, India and Japan, but no breeding for stem borer resistance has as yet been undertaken.

Besides stem borers, three other lepidopterous insects that cause damage to rice are, the swarming caterpillar (*Spodoptera mauritia* Boisd.), the army worm (*Cirphis unipuncta* Haw.) and case worm (*Nymphula depunctalis* Guer.). Of these, the swarming caterpillar is endemic in parts of India. It can prove destructive to the crop, particularly in the early stages, in the seed beds and in the transplanted crop. Dusting BHC at the rate of 44 kg./ha. is said to give effective control. The case worm occasionally causes serious damage to rice. The caterpillars are semi-aquatic in habit and are able to breathe under water. Spraying with DDT is reported to have given successful results (Ghose *et al.*, 254-55 : Grist, 248-49).

Paddy Bugs—There are a number of sucking insects attacking the vegetative parts and some attacking the ear at the grain formation stage and causing great damage. The stink or rice *gundhi* bugs, *Leptocoris acuta* Thunb. and *L. varicornis* F., are two commonly recognized pests, *L. acuta* being more important and seriously affecting all early maturing types in India. They appear in swarms just when the crop is in ears and grain is in the milk stage. They suck the sap from the developing grain, the attacked grains becoming half-filled or chaffy; the loss is often serious. The period of infestation being short,

a systematic hand-netting and destruction of the insect was found to control the insect although not completely. Application of 5% BHC dust at 11 kg./ha. is recommended against this pest. Application of DDT either as dust or spray has also proved effective in Malaya [Ghose *et al.*, 253 ; Grist, 252 ; Sen, *Rice News Teller*, 1960, 8(2), 6].

Species belonging to the genera, *Nephrotettix*, *Tettigoniella*, *Nilaparvata* and *Sogata*, are reported to cause serious damage to rice in many countries, particularly in India, Pakistan and Ceylon. They pierce the plant tissue and suck up the plant sap. Some of the hoppers transmit virus diseases. There may be three or more generations in a year. Large quantities of honeydew may be secreted by some of these insects, leading to sooty moulds on the leaf. The attack of the insect in South India is followed by the appearance of rice sclerotium disease, which is liable to be mistaken as the primary cause of trouble. Studies in Madras have shown that the heavy yielding rices characterized by luxuriant growth are the worst attacked. Some varieties also show resistance to this insect. Since the sclerotium disease usually follows the insect incidence, control measures are necessary at the very early stages. Dusting with 5% BHC is said to give perfect control. Parathion, either as 0.1% emulsion or 1.5% dust, was also found effective for at least 10 days against leaf hoppers in Japan. In Malaya spraying with BHC and DDT has proved successful (Ghose *et al.*, 254-55).

Other Minor Pests—Rice Mealy Bug (*Ripertia oryzae* Gr.) is generally found in numbers inside the leaf sheath, sucking up the nutrition and retarding the growth of the plant. Early maturing types usually escape the attack of the insect. The habit of the insect is said to make effective control very difficult.

Rice Thrips (*Thrips oryzae* Will.) is mainly a pest of the rice nurseries in transplanted areas, but can also appear in the young crop 2-3 weeks after direct sowing in the field. It sucks the sap from the leaves and causes a characteristic symptom of drying and rolling of the leaves and, in a bad case of attack, a scorched appearance to the whole field. Spraying the crop with tobacco infusion or DDT or BHC at 0.1% strength gives effective control. Endrin and Folidol have proved more effective (Ghose *et al.*, 256).

Rice Hispa (*Hispa armigera* Oliv.) is a beetle pest common on rice in India. The adult insect eats up the green matter of the leaves of young plants giving the characteristic appearance of parallel lines. With increased spacing of the plant in transplanting, the

incidence of this pest also increases. Since the young grubs generally feed on the terminal portions of young leaves, pruning of the tops of leaves and destroying them gives relief. Spraying with 0.25% BHC at 1,125 litre per hectare substantially reduces the pest population, while the adult beetle is effectively controlled by dusting the plant with 5% BHIC or DDT [Agarwala, *Indian J. Ent.*, 1955, 17(1), 11].

Rice Gall Fly [*Pachydiplopsis oryzae* (W.M.) Mani] occurs sporadically and occasionally proves a serious pest. The maggot of the fly burrows into the shoot and causes the characteristic tubular galls, and this may somewhat encourage tillering. The adult midge is said to exhibit varietal preference. Scented types and types with deeply pigmented foliage are said to be comparatively less attacked by the insect than non-scented types and types with no pigment in the foliage. Many of the very early maturing rices are less attacked than the later ones (Ghose *et al.*, 75, 252).

The insect has several alternate hosts, and there are also some parasites attacking the larvae of the fly. Dusting the crop with 5% BHC or spraying 0.08% Folitol or 0.04% Endrin to synchronize with the fly emergence is found to minimize incidence. Investigations in Cuttack indicate possibilities of checking the pest by biological control (Ghose *et al.*, 252).

Rice Grasshopper (*Hieroglyphus banian* Fabr.) is a serious rice pest in parts of India. The egg masses which are normally laid under the soil hatch out with the first rains and the young nymphs attack the rice crop after it is transplanted. The most destructive phase is at the time when the crop is in shot-blade when the adults cut down the side leaves and gnaw at the base of the flag leaf and cut the nutrition supply to the developing ears. The loss sustained sometimes amounts to 10–15%. Dusting the crop with 5% or 10% BHIC kills the grasshopper completely (Ghose *et al.*, 254; Grist, 258).

Non-insect Pests—In most rice growing areas of the tropical region including India, the crab and the rats do considerable damage to the crop in the field.

Crabs, both sea crabs as well as land crabs, attack only the young plants in the seed bed or in the field immediately after transplanting and also cause damage indirectly by burrowing holes in the dykes making water control almost impossible. Keeping the field drained and maintaining water level as low as possible minimizes the damage. Catching them either by hand or by special baited pots sunk into the field with the rim of the pot just above the water level and then destroying them have been

found effective. Fumigation with cyanogas is generally recommended (Ghose *et al.*, 256; Grist, 260).

Damage to rice by rats can be heavier than that brought about by insect pests. Three species of rats which cause damage to the rice crop are: Mole Rat, *Gunomys kok* G.; Gerbil or the Antelope Rat, *Tatera indica* H.; and Metad or Grass Rat, *Millardia meltada* G. Of these, the mole rat is the most destructive. The damage to the crop extends to all its stages, but reaches the peak when the crop is in ripe ears. The damage caused by this rodent is stated to be as much as 10%. Poison baiting and fumigating the burrows are the control measures practised. The poisons used in baiting are strichnine, barium carbonate, zinc phosphide, sodium arsenate and red squill, prepared from the bulbs of *Urginea maritima*, grown in N. Africa and the Mediterranean region; but zinc phosphide is the most popular and destructive poison. Among the fumigants used may be mentioned carbon disulphide, sulphur fumes and cyanogas. Baiting and fumigating have, however, not proved entirely successful in India, because all the burrows are not tenanted and the burrows get blocked with earth preventing the poison gas reaching the animal. Moreover, the mole rat is somewhat shy of the bait, zinc phosphide. Local methods of digging the burrows and killing the rats, and the use of the bow trap, a simple but ingenious contraption, have proved much more efficient. Critical studies in South India on the comparative merits of mechanical and chemical methods of control have shown that the number of rats exterminated by the former method was about seven times that effected by poison baits (Ghose *et al.*, 256; Grist, 263).

Insect Pests of Stored Grain—The most important insect pests of stored paddy and rice are said to be: Rice Weevil (*Sitophilus oryzae* Linn.); Paddy Grain Moth (*Sitotroga cerealella* Oliv.); Lesser Grain Borer (*Rhizopertha dominica* F.); Red Flour Beetle (*Tribolium castaneum* Ilbst.); Rice Moth (*Corypha cephalanica* H.); and Saw-toothed Beetle (*Oryzaephilus surinamensis* Linn.). Besides the above, mites also attack the grain during rainy weather and disappear with the onset of dry weather; in large numbers they impart a musty smell to the grain. The first two species infest the standing crop in the field at the time the grain is almost ripe, and this infestation is carried into the storehouse where they multiply. By fumigating the threshed paddy before storing in the warehouse, the incidence of the two insects can be avoided, provided measures are

also taken to prevent their later entry into the storehouse. The losses in storage depend, however, on the amount of moisture present in the grain during storage. Adjustment of the moisture content in the grain before storing and proper ventilation of the storehouse are the key factors to prevent losses in storage. Full information on the optimum moisture content for storing, methods of maintaining it and the best form of storehouse suitable for storing in tropical conditions with dry and wet seasons alternating is still lacking. In small holdings the farmer dries the grain to the required extent and the indigenous methods of storing followed by him are quite satisfactory and efficient. It is in large scale storing of either paddy or rice that the conditions are not controlled and losses occur. By controlling moisture and by judicious use of the chemicals as and when required, loss by insects can be greatly reduced (Grist, 297; Ghose *et al.*, 257).

A routine procedure of pest control is followed in India in Government managed warehouses where paddy is stored in bulk or in bags. BHC, ethylene dichloride and carbon tetrachloride are some of the chemicals used for control. Standards have recently been laid down for the construction of warehouses and storage practices to be followed therein. Experiments conducted to test some of the indigenous insecticides have shown that powdered rhizome of *Acorus calamus* (Sweet Flag) mixed with the grain at the rate of 1 kg. per 100 kg. of grain gave better control of *Rhizopertha*, *Sitophilus* and *Tribolium* than BHC or gammexane (Ghose *et al.*, 257; Grist, 302; Thomas *et al.*, *Allahabad Fmr.*, 1959, 33, 388).

Of the several forms of produce, paddy, i.e. grain in the husk is the easiest to store without damage by insects. Milled rice does not keep so well, since the loose bran particles on the surface attract insects; undermilled rice is particularly bad in this respect. Lack of ventilation also leads to the development of rancidity and greater insect infestation. Parboiled rice is comparatively less attacked by insects than milled rice in storage. In experimental trials, parboiled rice always showed smaller infestation than white rice, while the difference in infestation in rice milled to different degrees was not significant.

HARVESTING AND YIELD

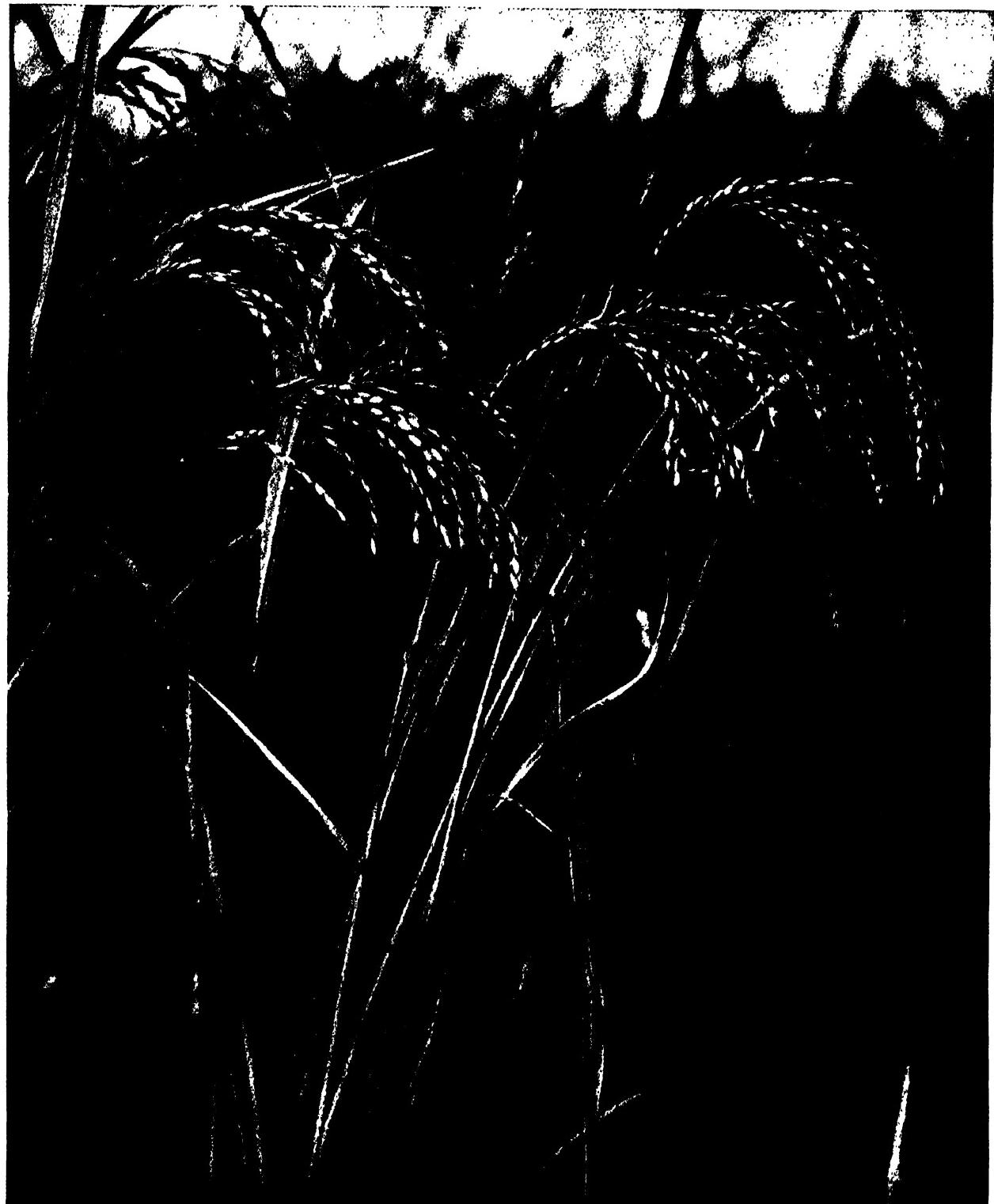
HARVESTING

Harvesting and threshing conditions are said to have a considerable effect on the quality of the harvested grain. Harvest may be hindered by

inclement weather or by lack of drainage in the fields. Draining the water 15–20 days before harvest, when the grains reach the dough stage, is said to lead to uniform ripening of the grain and facilitate harvesting and threshing. Moisture content of the grain at harvest and the methods adopted to reduce it before threshing and storing are said to have a considerable influence later on the milling quality of the paddy. Generally, early maturing varieties can be harvested one month after full flowering, while late maturing varieties cannot be cut before 6 weeks after flowering. Experiments in Uttar Pradesh are said to indicate that from the point of view of milling quality the optimum time of harvest is 32–35 days after full flowering for the early varieties and 46–50 days for the late ones. In Assam, different varieties have shown different optimum time for harvesting from the point of view of yield; maximum yields are obtained after 38, 46 and 54 days from full flowering for *Kersail*, *Badshabhog* and *Nagra* types respectively (Ghose *et al.*, 51; Subbiah Pillai, 80–82).

The determination of the optimum stage for harvesting, threshing, storing and milling is mostly empirical in India. Harvesting the crop while the straw is still somewhat green and slow drying of the sheaves before threshing lead to better milling quality. In Andhra Pradesh, the sheaves are dried for several days and then stacked, the threshing being done several months later in the off season; it is claimed that by following this practice threshing is made easier and the grain retains a good milling quality. In many parts of India, where dry weather prevails at harvest time and the land dries up quickly, the moisture content in the grain is never more than 18–20%. This may be a right condition for further reducing the moisture to 14% before threshing. In Japan, the moisture content of the grain is about 20% at the time of harvest and is reduced to 16% at the time of threshing, and this is further reduced to 13%, by further drying of the grain before it is husked. In Thailand, which is known to produce good quality rice, the crop is harvested when the grain has a moisture content as high as 25% or more. In U.S.A., it has been found that with a moisture content of 20–27% before harvest, the grain has a high milling quality, while a moisture content below 20% results in a low mill yield (*Agric. Marketing India, Rep. Marketing Rice, Marketing Ser.*, No. 75, 1954, 142; Grist, 131).

In some areas where harvest has been delayed, the moisture content may get reduced to 14 or 15% even



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ORYZA SATIVA — WITH EARHEADS



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FIG. 69—HARVESTING PADDY

before harvest and the straw becomes quite dry. The quantity of moisture that can be left in the grain with safety is said to be about 10-12%. Sun drying, often adopted to reduce moisture in the threshed grain, results in poor milling quality of the grain. In parts of South India, where sun drying is adopted, the development of suncheck is very common; such grain can be used mainly for preparing parboiled rice.

RATOON CROPPING

Raising a ratoon crop of paddy is not a common practice in this country but is said to be done on a small scale in some areas round about Chingleput in Madras State. The main crop is harvested in December-January and then the field is irrigated, weeded and manured and the stubbles allowed to shoot up. Trials carried on in Coimbatore and Cuttack are said to show that the capacity to produce a ratoon crop is a varietal character. The main crop should be cut when it is still green and the soil should be wet; best results are obtained when the crop is cut about 35 cm. from ground level. The height of the plant, length of panicle, size of spikelet

and grain of the ratoon crop are said to be in general lesser respectively than those obtaining in the main crop. The ratoon crop in the trials conducted at Coimbatore came to harvest in 72-73 days after the harvest of the main crop and the yield was almost equal to that of the latter in the case of some of the rices tested. Considerable saving in time, labour and cost is said to be possible by resorting to this technique wherever it is possible but it is not generally recommended since it is likely to increase incidence of pests [Ramiah, 80; Reddy & Pawar, *Andhra agric. J.*, 1959, 6, 70; Evans, *World Crops*, 1957, 9, 227; Evatt, *Rice J.*, 1958, 61(6), 18; Grist, 139].

THRESHING

The two most common threshing practices in this country are: (1) beating the sheaves against a hard surface, and (2) allowing the sheaves to be trodden by animals. The beating may be done immediately after harvest in the field itself or in the homestead. The treading by animals is invariably done in the field on a specially prepared ground. Where the straw is used mainly for animal feed, the straw after the beating process may be tread by



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FIG. 66—THRESHING AND WINNOWING PADDY

animals, not only to remove any grain that may be still left over, but also to bruise it and make it soft and less wasteful for animal feeding. With the existing threshing practices, the grain remains mixed with chaff, pieces of straw, mud particles and half-filled light grains and the usual method of winnowing against the prevailing wind removes only chaff and pieces of straw (*Rep. Marketing Rice*, 1954, 142-45; Subbiah Pillai, 82).

A pedal thresher used in Japan has been introduced in India and found satisfactory in many areas. In parts of Andhra Pradesh, tractors hired on contract basis have been used for threshing and found to finish threshing more quickly and more satisfactorily than by animals. Use of a power thresher driven by an oil engine or electric power has been tried in some places and proved satisfactory. Here, in addition to threshing, the machine does the sieving and winnowing at the same time. A pedal thresher has an output of c. 100 kg. paddy per hour while a power thresher of 1.0 h.p. has a capacity of c. 270 kg. paddy per hour (Ghose *et al.*, 65; Grist, 133).

YIELD

The rice crop is said to exhibit a wider range of yield per hectare than perhaps any other cereal as the condition under which it is grown ranges from primitive peasant farming to scientific cultivation. The highest yields are found in the sub-tropical and

temperate zones where the Japonica rices which respond to heavy fertilization, are grown, as in Japan, Italy, Spain, Egypt, Australia, and California in United States, where the average yields lie between 1,120 and 1,680 kg./ha. (Table 13). Yields are low in India as well as in the other rice producing countries of South and South-East Asia. The yield of rice in India differs from region to region and even from State to State in the same region. Table 14 gives the yield of rice in different States based on crop-cutting surveys. The yield per hectare is generally higher in the States falling in the southern region. In the eastern region, while the yield in Assam and West Bengal compares somewhat favourably with that in the southern region, it is low in Bihar and Orissa. In Madhya Pradesh in the western region and in Uttar Pradesh in the northern region, the yield rates are again low, but in Maharashtra they are generally higher (*Ramiah & Rao*, 284-87; *Rice Economy of India*, 7; *Rep. Marketing Rice*, 1954, 19-20).

TABLE 13—YIELD OF RICE (MILLED EQUIVALENT) IN DIFFERENT COUNTRIES*
(kg./ha.)

	1957-58	1958-59	1959-60	1960-61	1961-62
Australia	3,741	4,381	4,358	3,877	4,361
U.S.A.					
California	3,477	3,514	3,766	3,830	3,847
Southern States	2,323	3,246	2,436	2,473	2,482
Spain	3,803	3,803	3,815	3,640	4,198
Japan	3,264	3,403	3,501	3,578	3,459
Egypt	3,489	3,113	3,301	3,301	3,311
Italy	3,338	3,479	3,665	3,049	3,735
Peru	2,711	2,380	2,649	2,707	2,857
Taiwan	2,147	2,221	2,184	2,286	2,218
Malaya	1,381	1,270	1,507	1,606	1,492
British Guiana	1,055	1,231	1,381	1,396	1,227
Ceylon	1,154	1,166	1,231	1,243	1,253
Indonesia	1,079	1,092	1,117	1,129	1,153
Burma	917	1,117	1,142	1,105	1,105
Brazil	991	991	1,055	1,092	1,077
Pakistan	929	880	979	1,068	1,105
India	791	941	941	1,016	1,012
Thailand	828	917	867	892	940

* *Grain Crops*, Commonwealth Econ. Comm., No. 8, 1962, 126, Table 81; No. 9, 1963, 138, Table 81.

In comparing yields per hectare in India with those in other countries, it must be stated that yield in India is estimated on the basis of area sown to rice, while in other countries it is based on area harvested. Further in India more than one crop is raised in the same field and is estimated separately, while in other countries generally only one crop is raised. Variation in yield among different States and regions in India is mainly due to variations in soil, climatic conditions, including temperature and day length, growing season, varieties of rice grown and irrigation facilities available and also due to methods of yield estimation based on standard yield and conversion factor from paddy to rice (*Rep. Marketing Rice, 1954, 13-19; Rice Economy of India, 7-8*).

The yield of rice varies considerably in different countries from over 3,900 kg./ha. in Spain to about 590 kg./ha. in some of the south Asian countries. In India, the average yield is about 900 kg./ha. though in areas with better water facilities, manuring, and improved varieties it is higher. With intensive cultivation, yields of 3,000-6,000 kg./ha. have been recorded. A large number of factors have been shown to affect yield. Highest yields are reported from warm temperate regions growing Japonica rices under temperatures not below 70°F. and long days with intense insolation during growing period. The Japonica rices respond to intense fertilizing and produce higher yields than the Indica rices which respond to fertilizers only up to a point. It has been claimed that by using the so-called Japanese method of cultivation, the increases in yield have been quite remarkable. According to some, the higher yields in sub-tropical and warm temperate regions are due to climatic factors favouring the physiological activity of the plant, use of Japonica rices and the rotational crop system practised. On the other hand, it has been pointed out that the higher yields may be more due to such factors as the absence of drought and flood hazards, use of manures, better seed and better cultivation practices. By planting improved seed, particularly of one single strain, instead of a large number as at present in any one area, and by improved cultural practices, including plant protection methods and judicious use of fertilizers and irrigation facilities, it is possible to nearly double the average yield obtained at present (Ramiah, *Emp. J. exp. Agric.*, 1951, 20, 161; Ramiah & Rao, 288-94; Ramiah, *Agric. Developm. Pap., FAO, No. 45, 1954*; Grist, 358-66).

TABLE 14—YIELD OF RICE IN DIFFERENT STATES IN INDIA*

	(kg./ha.)		
	1960-61	1961-62	1962-63
<i>Southern Region</i>			
Andhra Pradesh			
Autumn (Abi)	1,279	1,350	1,196
Summer (Tabi)	1,089	1,249	1,299
Madras	1,405	1,498	1,495
Mysore			
Autumn	1,382	1,357	1,399
Kerala			
Autumn	n.a.	1,147	1,246
Winter	n.a.	1,478	1,460
Summer	n.a.	1,627	1,509
<i>Eastern Region</i>			
Orissa			
Autumn	n.a.	557	640
Winter	n.a.	969	863
Bihar			
Autumn	500	456	498
Winter	929	928	876
Assam			
Autumn	708	724	570
Winter	1,043	1,029	942
West Bengal†	1,183	1,083	990
<i>Northern Region</i>			
Uttar Pradesh	723	787	730
Punjab	1,019	1,085	1,010
Himachal Pradesh	1,171	1,109	860
Jammu & Kashmir	1,585	1,583	1,617
<i>Western Region</i>			
Madhya Pradesh	882	879	584
Gujarat	521	903	706
Maharashtra	1,037	1,151	873
All India**	987	1,024	926

* Consolidated Results of Crop Estimation Surveys on Principal Food Crops, Directorate of National Sample Survey (Agric. Statist. Div.), India.

** Average of all States covered.

† Data from Directorate of Econ. & Statist., Minist. Food & Agric., Govt. India.

n.a.—not available.

STORAGE

The grain obtained after threshing is either stored by producers for their own consumption and seed purposes or is marketed to rice mills or to Government agents. It is said that in South-East Asia losses due to bad storing are even more important than losses in milling. The storage is entirely in the shape of paddy, because paddy is less susceptible to deterioration in storage. The receptacles in use for storage vary in size and in the material used for construction. They may be temporary or semi-permanent, but always cheap. Cylindrical bins made of unbaked clay rings placed one over the other and plastered with clay and cowdung at the joints both outside and inside are very common. When the bin is completely filled the top is also plastered with clay and the outlet for the grain is left at the bottom of the bin. The capacity of bins may vary from 500 to 2,000 kg. Smaller bins of baked clay or galvanized sheets are also used. Even jute bags of 70-80 kg. capacity are often used. These bags are usually kept inside the dwellings or under a protected roof. A larger receptacle (5,000-7,000 kg. capacity) may consist of a rectangular elevated structure of plaited bamboo, built on piles and with a sloping thatched roof. There are also large rectangular bins, constructed indoors with walls made of wooden planks or galvanized iron sheets on all sides with a narrow outlet on one side. Often in parts of South India temporary circular bins of 2,000-5,000 kg. capacity are constructed of twisted rice straw on masonry floors. Paddy is also stored for short periods of not more than a few months in underground pits with a narrow mouth, which is sealed off with a flat stone slab and plastered with mud after the pit is filled. This underground method of storage is preferred in some places as it is said that the milling quality of the paddy and the cooking quality of the milled rice improve by such storing. Unless the receptacle is filled up to the top and made as airtight as possible, damage to the grain by the rice moth (*Sitotroga cerealella* Oliv.) is very common. Where the grain is intended for seed, the receptacles are kept in a cool ventilated place (*Rep. Marketing Rice*, 1954, 135-40; *Rice Economy of India*, 72-73).

Majority of the mills store the paddy in *Kothas*, a battery of rooms built of brick and mud or mortar and provided with a door and window. The paddy is stored over a 15 cm. layer of paddy husk spread on the ground. Occasionally paddy is stored in jute bags, particularly when they are to be milled in the near

future. Paddy held by Government is stored in warehouses under technical supervision and plant protection. Insect pests affecting stored grain and their control have been dealt with earlier (*Rice Economy of India*, 74-76).

COMPOSITION

The mature grain or paddy is botanically called caryopsis and consists of a loose outer husk enclosing the kernel. The husk varies in thickness as well as the ease with which it separates from the kernel in different types of rice. It constitutes up to 25% of the paddy. The kernel itself is made up of three parts, viz. the outer layers which include the pericarp (or seed coat) with the underlying aleurone layer, the starchy endosperm, and the germ (or embryo), which on the average amount respectively to 6.0, 91.75 and 2.25% of the grain. The aleurone layer is generally thicker in Japonica than in the Indica rices. In the Indica rices, maximum development of aleurone layer is observed in rices with purple or coloured pericarp and in larger, bolder grains, than in fine and slender ones. The endosperm is of two kinds the glutinous and the non-glutinous, the former being more sticky when cooked than the latter. The germ, the pericarp, and the aleurone layer, which are richer than the endosperm in nutrients like proteins and vitamins, are separated from the grain during milling along with the husk, the amounts removed varying to a greater or lesser extent, depending upon the mode and extent of processing.

The chemical composition of rice is influenced to some extent by genetic and environmental factors. Analysis of 14 types of husked rice from different parts of India gave the following ranges of values: moisture, 10.90-13.78; ether extr., 0.59-2.59; protein, 5.50-9.32; carbohydrates, 73.35-80.81; fibre, 0.18-0.95; and mineral matter, 0.79-2.00%. An investigation of *aus* and *aman* rices of Bengal shows that both the types are somewhat poorer in protein and fat than the rices from other parts of India. *Aman* rice has a higher content of protein, fat and potash than the *aus* type. Examination of raw rices in the Madras State shows that the coloured and coarse grained types are generally richer in protein, phosphorus and calcium than the fine grained types; the former have also thicker aleurone layers (Sreenivasan, *J. sci. industr. Res.*, 1951, 10A, 438; Sen, *Bull. agric. Res. Inst. Pusa*, No. 70, 1917, 39-40; Basu & Sarkar, *Indian J. med. Res.*, 1934-35, 22, 745; Sadasivan & Sreenivasan, *Indian J. agric. Sci.*, 1938, 8, 807).

Application of nitrogenous fertilizers in several doses up to the flowering stage is stated to increase the grain yields as well as the protein and mineral contents of the grain. A study of the effect of different fertilizers on the thiamine content of rice indicates that the addition of nitrogenous fertilizers alone increases the vitamin content, while potash alone has no effect. It is reported that rice grown on alluvial soil with a moderate rainfall has a higher percentage of protein, calcium and phosphorus than that grown on lateritic soils. However, variations in the chemical composition of rice due to type and environmental factors are outweighed in importance by the effects of milling and other processes to which rice is subjected, after it has been harvested. The chemical composition of home-pounded and milled rice, raw as well as parboiled, is summarized in Table 15 (Sreenivasan, *J. sci. industr. Res.*, 1951, **10A**, 438; Sathe *et al.*, *Sci. & Cult.*, 1951-52, **17**, 134; Basak *et al.*, *Indian J. agric. Sci.*, 1961, **31**, 113; FAO nutr. Stud., No. 1, 1954, 15-17).

Starch is the major constituent of rice. The amylose content of the starch varies according to grain type; the longer grained and superior types contain up to 17.5% of amylose whereas some of the coarse types are completely devoid of it. Starch in glutinous rice is reported to consist almost entirely of amylopectin.

The difference in starch composition is probably one of the factors responsible for the difference observed in the cooking quality of rices. Freshly harvested rice contains: starch, 72.2-74.9; glucose, 1.45-2.65; sucrose, 0.30-0.48; and dextrin, 1.56-2.05%; no marked change is reported in the amount of carbohydrates during storage. Small amounts of fructose and galactose and in some samples raffinose are also present. Maltose, isomaltose, maltotriose and maltotetrose identified in old rice are all formed possibly due to some starch being hydrolyzed by α -amylase during storage. Hemicelluloses of rice are made up of arabinose and xylose (approximately 1:1) and small quantities of galactose, mannose and uronic acid (Rao *et al.*, *Proc. Indian Acad. Sci.*, 1952, **36B**, 70; Radley, I, 76; Sreenivasan, *Indian J. agric. Sci.*, 1939, **9**, 208; *Chem. Abstr.*, 1958, **52**, 7440; Parihar, *Nature, Lond.*, 1955, **175**, 42; Bevenue & Williams, *J. agric. Fd Chem.*, 1956, **4**, 1014).

The protein content of rice is lower than that of wheat and maize, but otherwise the three cereals do not differ materially in nutritive value (Table 16). One-fourth of the protein of the whole rice is contained in the bran and polish; the germ, aleurone layer and one or two layers of the cells of the endosperm adjacent to the aleurone layer are rich in protein. A glutelin, named oryzénin, is the principal

TABLE 15—CHEMICAL COMPOSITION OF DIFFERENT KINDS OF RICE

	Raw Rice			Parboiled Rice		
	Husked*	Home-pounded*	Undermilled*	Milled*	Home-pounded†‡	Milled†
Moisture, %	9.7	9.6	9.5	9.7	12.6	13.3
Protein, %	7.7	7.3	7.2	6.9	8.5	6.4
Fat, %	1.8	1.2	0.95	0.54	0.6	0.4
Carbohydrates, %	78.1	80.1	80.95	82.06	77.4	79.1
Claude fibre, %	1.1	0.7	0.5	0.2	..	..
Mineral matter, %	1.6	1.1	0.9	0.6	0.9	0.8
Calcium, mg./100 g.	15.9	13	13	10	10	10
Phosphorus, mg./100 g.	368	182	146	87	280	150
Iron, mg./100 g.	4.0	2.8	2.5	2.2	2.8	2.2
Thiamine, $\mu\text{g}./100 \text{ g.}$	360	210	190	105	270	210
Nicotinic acid, mg./100 g.	3.5	2.5	2.2	1.0	4.0	3.8

* Subrahmanyam *et al.*, *Bull. cent. Ed. technol. Res. Inst., Mysore*, 1955, **56**, 5, 214, 329.† *Hlth Bull.*, No. 23, 1951, 28.‡ Carotene (as vitamin A), 15 I.U./100 g.; and riboflavin, 120 $\mu\text{g}./100 \text{ g.}$

ORYZA

protein of rice. Small quantities of an albumin, α - and β -globulins (coagulating at 74° and 90° respectively), and prolamines (gliadins) are also present; α -globulin was reported in *aus* rice and β -globulin in *aman*. The oryzelin content of glutinous rice is higher than that of non-glutinous rice. It is reported to be absent in the bran. Prolamines and globulins appear to be concentrated in the bran. During the ripening of rice, protein nitrogen increases at the expense of the non-protein nitrogen; the amounts of globulin and prolamine increase whereas the albumin content decreases; and oryzelin reaches its highest concentration shortly before ripeness. The nitrogen distribution in oryzelin is as follows: amide N, 10.70–11.33; humin N, 0.86–1.59; cystine N, 0.88–1.56; arginine N, 16.36–21.80; histidine N, 3.68–6.42; lysine N, 1.26–7.35; amino N of filtrate, 52.13–54.33; and non-amino N of filtrate, 2.30–5.28% of total nitrogen (Ramiah & Mudaliar, *Indian J. agric. Sci.*, 1939, **9**, 39; McCall *et al.*, *Bur. agric. industr. Chem., U.S. Dep. Agric.*, AIC-312, 1951, 9–14; Basu & Basak, *Indian J. med. Res.*, 1936–37, **24**, 1067; Thorpe, II, 492; Winton & Winton, I, 142–44).

The biological value and digestibility co-efficient of proteins of rice and its milled products are presented

TABLE 17—BIOLOGICAL VALUE AND DIGESTIBILITY CO-EFFICIENT OF RICE PROTEIN*

	Protein content	Level of protein intake	Biological value	Digestibility co-efficient
	(%)	(%)	(%)	(%)
Rice, husked	7.5	6	72.7	96.5
Rice, polished	6.5	6	66.6	98.0
Rice bran	12.3	5	84.9	77.6
Rice polishing	12.7	5	82.9	91.3
Rice germ	14.9	6	78.1	86.9

* Kuppuswamy *et al.*, 14–16.

in Table 17. It is found that proteins of husked and of polished rice have a lower biological value but a higher digestibility than those of rice bran and rice polishing. Parboiling has no effect on the biological value or digestibility of the protein of polished rice. The nutritive value of rice protein as determined both by animal experiments and human metabolism studies is of a high order, being superior to wheat and other cereal proteins. The essential amino acid make-up of the proteins of 6 Indian types of husked rice (moisture, 8.9–11.4; and total N, 1.09–1.58%) was as follows: arginine, 7.92–12.46; histidine, 1.3–2.0; lysine, 3.2–4.4; tryptophan, 1.15–1.50; phenylalanine, 4.3–5.0; methionine, 2.1–2.6; threonine, 3.25–3.62; leucine, 7.38–9.41; isoleucine, 5.46–6.74; and valine, 5.60–7.80 g./16 g.N. The proteins appear to be rich in arginine compared to those of other cereals. They are deficient in lysine and threonine; more recent studies have indicated that threonine may not be a limiting amino acid (Kik, *Cereal Chem.*, 1939, **16**, 441; Swaminathan, *Indian J. med. Res.*, 1936–37, **24**, 767; Basu & Basak, *ibid.*, 1936–37, **24**, 1043; Mitra *et al.*, *ibid.*, 1948, **36**, 261; Basu *et al.*, *ibid.*, 1941, **29**, 105; Balasubramanian *et al.*, *ibid.*, 1952, **40**, 73, 219; Balasubramanian & Ramachandran, *ibid.*, 1957, **45**, 623; Sure & House, *J. Nutr.*, 1948, **36**, 595; Altschul, 337–40).

Polypeptide and free amino acids occur in rice; amino nitrogen amounts to 0.75–1.02% of the total nitrogen, the corresponding values for acid amide nitrogen being 0.14–0.23% and for polypeptide nitrogen 0.85–1.15%. Free amino acids identified in rice are alanine, tyrosine, proline, glutamic acid, aspartic acid and cystine, besides all the essential amino acids. Nitrogenous compounds reported in the bran include

TABLE 16—CHEMICAL COMPOSITION OF RICE, WHEAT AND MAIZE*

	Rice		Wheat		Maize
	Husked	Milled	Whole	White flour	Whole
Protein, %	8.9	7.6	11.1	9.3	10.0
Fat, %	2.0	0.3	1.7	1.0	4.3
Carbohydrates, %	77.2	79.4	75.5	77.2	73.4
Fibre, %	1.0	0.2	2.4	0.4	2.3
Ash, %	1.9	0.4	1.8	0.5	1.5
Thiamine, $\mu\text{g/g}$	3.5	0.6	1.0	3.2	7.7
Riboflavin, $\mu\text{g/g}$	0.8	1.0	0.28	1	1.2
Nicotinic acid, $\mu\text{g/g}$	55	15	20	53	10.00
Pantothenic acid, $\mu\text{g/g}$	17	6.4	13.4	5.70	8†
Pyridoxine, $\mu\text{g/g}$	10.3	4.5	4.6	2.20	..
Choline chloride, $\mu\text{g/g}$	...	880	920	520	370†

* FAO *nutr. Stud.*, No. 1, 1954, 64.

† Yellow corn.

guanine, xanthine, adenine, hypoxanthine, ammonia, di- and trimethyl amines, guanidine, amino acids, and uracil. Allantoin is found in the extract of rice polish (Thorpe, II, 493; McCall *et al.*, *Bur. agric. industr. Chem., U.S. Dep. Agric.*, AIC-312, 1951, 11; Parihar, *Naturwissenschaften*, 1954, **41**, 502).

Whole rice is a good source of some of the B-vitamins, particularly thiamine, pantothenic acid and pyridoxine. The riboflavin content is low and ascorbic acid is practically absent. The amount of fat-soluble vitamins A and D is negligible but the vitamin E (tocopherol) content is considerable; α -, ξ -, and η -tocopherols have been identified in the unsaponifiable portion of the bran oil. The thiamine and riboflavin contents differ among types and to a slight extent with geographical location. The niacin content is not influenced by location of growth and there is only a minor variation with the type. The thiamine content of glutinous rice has been found to be quite high (over 3 $\mu\text{g./g.}$), the darker types containing a higher amount than the white. Data on the vitamin contents of rice are given in Tables 15, 16 and 18 (*FAO nutr. Stud.*, No. 1, 1954, 14-15; McCall *et al.*, *Bur. agric. industr. Chem., U.S. Dep. Agric.*, AIC-312, 1951, 14; Green & Marcinkiewicz, *Nature, Lond.*, 1956, **177**, 86).

Thiamine is concentrated mostly in the germ and the aleurone layer. The distribution of thiamine in a sample of rice was found to be as follows: scutellum, 44; aleurone layer, 35; germ, 12.3; and endosperm, 8.8%. Another investigation on the distribution of thiamine and riboflavin in rice grains confirmed that the maximum concentration of thiamine occurs in the germ, mainly in the scutellum and the adjacent cells of the endosperm, and also indicated that riboflavin is more uniformly distributed throughout the tissue of the germ than thiamine. Niacin is present mostly in the pericarp and the adjacent layers of the endosperm; a major portion of it occurs in bound form (*FAO nutr. Stud.*, No. 1, 1954, 14-15; Aykroyd *et al.*, *Indian med. Res. Mem.*, No. 32, 1940, 23-25, 34-36; Mitra & Chaudhuri, *Ann. Biochem.*, 1957, **17**, 49).

In its mineral content, rice resembles other cereals. Most of the minerals present in rice are located in the pericarp and germ. The mineral content of milled rice is c. 0.5% and that of husked rice, 1-2.5%. Rice, particularly the polished grain, is poor in calcium and iron. The calcium content of 22 types from the Madras State varied from 14.3 to 85.7 mg./100 g. for the husked rice, and 7.1 to 42.8 mg./100 g. for the

TABLE 18—VITAMIN CONTENT IN RICE AND RICE PRODUCTS*
($\mu\text{g./g.}$, dry wt. basis)

	Paddy	Husked rice	Polished rice	Bran	Polish	Germ†‡
Thiamine	3.35	2.00	4.80	0.0-3.01	27.9	23.3
Riboflavin	0.73	0.60-0.61	0.24-0.26	2.14-4.0	1.8	5.0
Nicotinic acid	..	46.2-47.2	12.7	408.6	384.7	33.0
Pantothenic acid		10.3-17.0	6.4	71.3	92.5	30.0
Pyridoxine		10.3	4.5	32.1	30.8	16.0
Biotin		0.12	0.04	0.47	0.66	0.58
Vitamin E		29	..	30	..	..

* McCall *et al.*, *Bur. agric. industr. Chem., U.S. Dep. Agric.*, AIC-312, 1951, 15.

† Kik, *J. agric. Ed. Chem.*, 1954, **2**, 1179.

‡ Germ contains also: *p*-Aminobenzoic acid, 1.0; inositol, 3,725; folic acid, 4.3; and choline, 3,000 $\mu\text{g./g.}$.

polished rice. The calcium-phosphorus ratio is unfavourable for their efficient utilization, being about 1:10 instead of 1:2 which is regarded as the optimum. Some types of rice have a high content of phosphorus (171.6-558.8 mg./100 g. in the husked and 52.8-211.2 mg./100 g. in the polished rice), of which c. 40% is present in the phytin form. The distribution of phosphorus in the husked rice is as follows: phytin P, 39.9; nucleic acid P, 46.1; P in combination with carbohydrates, 10.3; inorganic P, 3.0; and phosphatide P, 0.8%. Over 50% of the total phosphorus of husked rice is concentrated in the germ and pericarp fractions. The phytate in the grain adversely affects the utilization of calcium and iron. Coloured types of rice are reported to contain much more iron than the white rice [*FAO nutr. Stud.*, No. 1, 1954, 15; Ramachandran & Patwardhan, *Indian Eng. N.S.*, 1956-57, **6**(8), 51; Sadasivan & Sreenivasan, *Indian J. agric. Sci.*, 1938, **8**, 807; Subrahmanyam *et al.*, *ibid.*, 1938, **8**, 459; Sreenivasan, *J. sci. industr. Res.*, 1951, **10A**, 438].

Rice contains sodium (20 mg./100 g.), potassium (100 mg./100 g.), magnesium, sulphur and chlorine. Being low in sodium content, rice is considered useful as a staple cereal in low-sodium diets. Trace elements reported in the grain include aluminium, manganese, copper, zinc, arsenic, boron, chromium, nickel, cobalt, iodine, fluorine, selenium, titanium, molybdenum, vanadium, lead, tin, strontium, barium,

rubidium and lithium. More than 65% of the iodine in the whole grain is found in the bran fraction (Pain & Banerjee, *Indian J. med. Res.*, 1956, **44**, 749; McCance & Widdowson, 27; Ramachandran & Patwardhan, loc. cit.; McCall et al., *Bur. agric. industr. Chem., U.S. Dep. Agric.*, AIC-312, 1951, 22-23; Grist, 331; *Chem. Abstr.*, 1959, **53**, 7449; 1960, **54**, 21517).

The enzymes present in rice include α -amylase (optimum pH, 7), β -amylase (optimum pH, 4.6), amylosynthease, catalase, protease, lipase, phenolase, oxidase, peroxidase and an inhibitor which interferes with the oxidation of pyrogallol. The phenol reaction shown by the Indica rices is considered as due to phenolase, but the reason why Indica rices get stained and not the Japonica rices, is not known. The endosperm is rich in zymogen while the starch-liquefying enzyme, which is more thermostable than the dextrinizing and saccharifying amylase, is concentrated in the pericarp. The amylases can be extracted in an active state by extraction with phosphate buffer (M/15) at a pH of 7.0. During germination of rice to malt, the α - and β -amylases are transformed into the amylase system ($\alpha + \beta$), with an optimum temperature of 60°. The activity of catalase, oxidase and peroxidase is reported to be influenced by varietal and environmental factors. On storage, the oxidase activity of paddy remains constant but the amylase, lipase, catalase and peroxidase activity decreases. The active α -amylase in fresh rice is probably responsible for its sticky consistency after cooking. The presence of phosphatase, phytase, three water soluble phospho-mono-esterases and a phospho-di-esterase has been reported in the bran (Karmarkar & Patwardhan, *J. Indian Inst. Sci.*, 1931, **14A**, 47; Thorpe, II, 495; McCall et al., *Bur. agric. industr. Chem., U.S. Dep. Agric.*, AIC-312, 1951, 20-21).

The pigments occurring in the coloured types of rice are a mixture of monoglycosides of cyanidin and delphinidin. The dark Puttu rice contains a diglycosidic anthocyanin. Among the miscellaneous constituents in rice are a carotenoid, pectic substances (1.13%, on moisture-free basis), polyphenols, and two alkaloids, viz. stachydrine and trigonelline. Rice contains citric, acetic, fumaric, succinic, oxalic, malic and several aromatic acids including ferulic, vanillic, and *p*-coumaric acids. From polished rice, a toxic substance named lysolecithin ($C_{24}H_{50}NPO_2$, m.p. 262-64°) has been isolated; on hydrolysis it yields palmitic and glycerophosphoric acids and choline

(Sharma & Seshadri, *J. sci. industr. Res.*, 1955, **14B**, 211; Palmer, 88; Kertesz, 299; *Plant Breed. Abstr.*, 1960, **30**, 94; Willaman & Schubert, *Tech. Bull., U.S. Dep. Agric.*, No. 1234, 1961, 91; Houston et al., *J. agric. Fd Chem.*, 1963, **11**, 512; Winton & Winton, I, 150).

Some types of rice possess a characteristic sweet aroma which is recognized when the grain is boiled. The dehiscing anthers and empty glumes may also emit the fragrance. In India, the Basmati rice is highly esteemed for its peculiar aroma, which is said to resemble that of the flowers of *Madhuca longifolia*, and commands high prices. It is not definitely known in which part of the grain the scent is concentrated or to what active principles it is due (Ramiah, *Madras agric. J.*, 1937, **25**, 173).

PARBOILING

The rice grain is consumed after removing the outer husk by a process of milling, sometimes followed by polishing. Quite often the paddy is subjected to a treatment before milling known as parboiling, which involves soaking the paddy in water, steaming it in hot water and drying it in the sun. The husked grain obtained by milling without any pretreatment is known as Raw Rice in India, as against Parboiled Rice (HINDI—*Sela chaval, ushna chaval*; MAR.—*Ukada tandul*; TEL.—*Uppudu biyyamu*; TAMIL. & MAL.—*Puzhungal arisi*; KAN.—*Kusubalu akki*), obtained after parboiling.

The process of parboiling originated in India and is widely practised in this country since ancient times. In this process, paddy soaked in water for sometime is heated once or twice in steam and dried before milling. It is estimated that more than half of India's rice crop is parboiled before hulling. Parboiling is particularly significant in the case of coarse and medium rices of soft and chalky structure, because such rices suffer excessive breakage when milled raw. Of the total production of parboiled rice, coarse types constitute c. 60%, medium c. 30%, and fine c. 10%.

Parboiling is done both at the household level and on a commercial scale. The household methods followed in different parts of the country are essentially the same, but the time allowed for steeping and heating, and the equipment used may vary. Paddy mixed with water is heated to the simmering or boiling point for a few minutes, after which it is transferred to the cold water steep for a period of 24-36 hr. It is then given another boil and dried

slowly, usually in the shade, and husked. Parboiled rice prepared by household methods is generally retained for home consumption. The domestic parboiled rice is incompletely gelatinized and has an opaque core which is preferred by certain sections of rice eaters. It is also generally less smelly or coloured than commercial parboiled rice ; however, it is not as hard as the latter and suffers comparatively higher breakage during milling. In Punjab and Uttar Pradesh, the parboiled paddy is given a slight roasting with sand in order to impart a pleasing fragrance to the grain (Ghose *et al.*, 373; *Rep. Marketing Rice*, 1954, 148).

There are two commercial processes of parboiling commonly employed in India, viz. Double boiling and Single boiling (or Cold soaking). In the Double boiling process, the paddy is placed dry in cast iron cylindrical containers and subjected to low-pressure steam for c. 1 min. to obtain a light coloured parboiled rice, or for c. 5 min. if a yellow coloured product is desired. The paddy is then discharged into large cement tanks, where it is steeped in cold water for 18-36 hr. The fermentation that sets in during soaking can be reduced by changing the soak water frequently. After draining out the water, the steeped paddy is conveyed back to the steaming cylinders and given a second application of steam, for c. 5 min. (for light coloured rice) or 9-10 min. (for yellow tinted rice), which completely gelatinizes the grain. The paddy is then spread out on cement floors for drying. It is dried slowly and uniformly ; sun drying usually gives satisfactory results. Double boiling process is stated to be prevalent in West Bengal, Bihar, Orissa, Madras and Mysore. In the Single boiling process, paddy after being steeped in cold water for 1-3 days is subjected to steam for a period of up to 10 min. and then dried. This method is generally employed where a light coloured product is preferred (Ghose *et al.*, 374).

Parboiling of paddy has several advantages. Steaming splits the husk making its subsequent removal easier ; the grain is toughened resulting in reduced breakage during milling and polishing, so that there is a greater out-turn of head rice. Milled parboiled rice has greater resistance to insect and fungus infestation and better keeping qualities than raw rice. Also, parboiled rice retains more of the nutrients during milling, washing and cooking. During steaming, thiamine and other water soluble nutrients, originally concentrated in the germ and aleurone layer, diffuse through the grain ; with proper par-

boiling, they are more or less homogeneously distributed throughout the whole kernel. When the germ and aleurone layer are removed by milling, the loss of water soluble vitamins is, therefore, much less than that occurring in the milling of raw rice. Finally, the parboiled rice cooks better than raw rice. It does not tend to turn into glutinous mass and retains its freshness after cooking for longer hours than raw rice.

Despite its advantages, parboiled rice is not preferred in several areas due to its inferior colour and often unpleasant smell, the latter mainly due to defective steps in parboiling. The characteristic off-flavour and a yellowish colour are mainly due to fermentation of paddy in the steeping tanks owing to growth of bacteria and fungi. Improved techniques of parboiling have been developed whereby maintaining a high temperature in the steeping tanks and reducing the soaking period to a few hours in the double boiling process, the quality of parboiled rice is improved. Two processes, viz. the Conversion process and the Malekising process, have been patented which are similar in principle to parboiling by hot soaking method. In the Conversion process, washed paddy is placed in a large vessel and hot water (75-85°) introduced under pressure. The paddy is steeped for 2-2.75 hr. after which it is heated by dried steam in cylindrical rotating vessels for a few minutes and then dried *in vacuo* in a rotating steam-jacketed vessel to a moisture content of less than 15%. The hot, converted paddy is cooled by passing air through it and keeping it in bins for at least 8 hr. before milling. The finished product has an attractive appearance with the nutritive properties of parboiled rice, and is also more resistant to insect attack than raw rice. The average retention of vitamins in converted rice is as follows: thiamine, 92.2 ; riboflavin, 70.8 ; and niacin, 77.6%. Malekising is a process similar to Conversion and involves soaking of paddy followed by steaming under pressure and drying. Converted (and also malekized) rice is superior to ordinary parboiled rice, but its cost of production is much higher. It may be possible, by suitable modification and adjustment of the various stages in parboiling, to produce cheaply a milled product with appearance and taste acceptable to rice eaters in general (*Rice Economy of India*, 39-40; *Rep. Marketing Rice*, 1954, 147-49; *FAO nutr. Stud.*, No. 1, 1954, 22-24; Ghose *et al.*, 373-77; Subrahmanyam *et al.*, *J. sci. industr. Res.*, 1955, 14A, 110; Desikachar *et al.*, *Res. & Ind.*, 1957, 2, 150; *Bull. cent. Fd technol. Res. Inst., Mysore*, 1955-56, 5, 50).

MILLING

Paddy is milled in India either by home-pounding, using such devices as wooden pestle and mortar or *chakki* (stone mill), or in small power-driven hullers and large mechanized rice mills. In Bihar, Orissa, West Bengal, Madhya Pradesh, Kerala, Assam and Uttar Pradesh, major part of the paddy is husked by home-pounding, while in Madras, Mysore, Punjab and Bombay, the mechanized process accounts for the bulk of the total rice production; the two processes are equally important in Andhra Pradesh. In 1953-54, the quantity of rice produced in the rice mills was estimated at 52.6% of the total production. Since then many new mills have been set up, but more recent data regarding the share of the mechanized and home-pounding processes in the total rice production are, however, not available (*Rep. Marketing Rice*, 1954, 77, 147, 150; *FAO nutr. Stud.*, No. 1, 1954, 3-4; *Rice Economy of India*, 32-34).

Home-pounding is most commonly done with the mortar and pestle made of wood and worked by hand or foot. In the type worked by hand, the paddy placed in a mortar is pounded by a heavy wooden pestle, c. 2 m. long, fitted with an iron hub at one end and an iron ring at the other. The type worked by foot is known as *dhenki* and handles

comparatively larger quantities of paddy. It consists of a short pestle, 30 cm. in length, fixed on the underside of a beam of wood which is c. 3 m. long and placed on a fulcrum. With these implements, the pounding is continued till the charge has been sufficiently husked, after which it is winnowed and polished by light hand-pounding. By winnowing, the bran (which comprises the pericarp and germ) is separated from the grains. In parts of Punjab, Uttar Pradesh and Maharashtra, a hand *chakki* is used, which employs two grinding discs (made of stone or wood) placed one upon the other and so adjusted that they grind the paddy and remove the husk (*Rice Economy of India*, 33-34; *Rep. Marketing Rice*, 1954, 151, 162-64).

Milling by power-driven machines is a well-established small-scale industry in India. The rice mills are generally located around the regions of production and the total number of rice mill establishments, large and small, in the country were estimated at 35,000 in 1958-59. The available information on the State-wise distribution of rice mills is summarized in Table 19.

Two types of rice mills are commonly used in India, viz. the hullers and the automatic shellers. The hullers are much more numerous and are comparatively cheaper. The handling capacity of an average sized huller is 160-225 kg. of paddy/hr. The automatic shellers are of various types and sizes. A typical establishment is capable of handling about 1,000-1,275 kg. of paddy/hr., while a larger mill has an hourly output of up to 1,725 kg. Some rice mills combine shellers and hullers which perform the husking and polishing respectively. Details regarding the machinery employed and their working are dealt with under Rice Milling Industry (cf. *With India—Industrial Products*, pt VII).

The product which emerges from a huller contains white rice and broken grains, mixed with bran and finely crushed husk, which can be separated by sifting. The grain suffers excessive breakage in hullers, and the bran which gets mixed up with powdered husk is generally not recovered in pure form. The rice mills usually employ a number of hullers, though single huller establishments are often found in rural areas. In the automatic sheller type mills, the cleaning, husking, winnowing, polishing and final sieving are all done automatically in a continuous process, delivering finally the rice, husk, bran, etc., separately. The sheller mills yield c. 10.0% more head rice than huller mills.



Indian Coun. Agric. Res., New Delhi

FIG. 67—HUSKING PADDY WITH A DHENKI

TABLE 19—STATE-WISE DISTRIBUTION OF RICE MILLS IN INDIA*

State	(1960)			Total (1960)	Total† (1963)
	Huller type mills	Sheller type mills	Combined huller- sheller type mills		
Andhra Pradesh	n.a.	n.a.	n.a.	4,667	6,810
Assam	60	2	262	324	433
Bihar	n.a.	n.a.	n.a.	745	2,219
Gujarat	1,533	128	129	1,790	1,877
Himachal Pradesh	n.a.	n.a.	n.a.	343	354
Kerala	2,615	66	3	2,684	3,549
Madhya Pradesh	1,501	79	253	1,833	2,372
Madras	7,299	95	6	7,400	7,411
Maharashtra	1,459	71	331	1,861†	2,672
Manipur	48	1	..	49	51
Mysore	2,506	461	93	3,060	3,830
Orissa	738	35	54	827	1,075
Punjab	1,529	85	38	1,652	2,263
Tripura	99	..	2	101	91
Uttar Pradesh	1,087	131	93	1,311	1,582
West Bengal	4,882	5	25	4,912	6,858
Andaman & Nicobar Is.	n.a.	n.a.	n.a.	18	46

* Rice Economy of India, 34.

† Relates to Greater Bombay and 21 districts only.

‡ Statistical Statements relating to the food situation, Minist. Food & Agric., Govt. India, Sept. 1964, 12.

n.a.—not available.

A polish is imparted to the rice kernels during home-pounding or machine-milling, in the latter case in a cone polisher (pearling cone). Further dressing or coating and colouring are done in some parts of India to give the grains an attractive appearance, or render the detection of adulteration with inferior rice difficult, or pass off newly harvested rice as old. Artificial colours used include powdered turmeric and red and yellow ochres. Gloss and lustre are imparted to the grain by using substances like wheat and corn flours, talc, powdered rock salt, castor oil, groundnut oil and white mineral oil. Application of these materials takes place at the finishing stage (Ghose *et al.*, 373, 377-81; Rice Economy of India, 32-35; Rep. Marketing Rice, 1954, 30, 151-54, 169-70; Grist, 314).

A control of the degree of milling is necessary, particularly in the case of raw rice, to retain the

adequate amounts of thiamine and other nutrients in the milled rice. Simple inspection of the end product can give a rough idea of the degree of milling to the experienced eye; the use of iodine, which stains the starchy endosperm showing how much of the pericarp and aleurone layer remain, has also been suggested. The best methods so far developed for processing control are based on the direct determination of nutrients in the milled product. Among these, the determination of thiamine content in the grains is the most important. Several methods which are generally time-consuming and involve absorption and elution procedures for the determination of the concentration of thiamine have been devised for this purpose. It has been suggested that the percentage loss of phosphorus during milling may also be used for assessing the extent of polishing of rice. There is a correlation between the thiamine and phosphorus contents in the grain; and to allow for varietal differences, the degree of milling could be expressed better in terms of percentage loss of the constituents rather than in terms of their absolute values in the polished grain. A simple and quick colorimetric method for the estimation of phosphorus in the rice grain has been developed at the Central Food Technological Research Institute, Mysore. Colorimetric methods based on the concentration of pigments present in the bran have also been devised to determine the degree of milling (Ghose *et al.*, 381-83; FAO nutr. Stud., No. 1, 1954, 29; Subrahmanyam *et al.*, Indian J. agric. Sci., 1938, 8, 459; Desikachar, Cereal Chem., 1955, 32, 71, 78, 80; 1956, 33, 320).

The paddy, freed from extraneous matter, yields on milling 74-75% of saleable products, viz. head rice, broken grains and bran, and 23-25% of husk. Percentage of rice, broken grains and bran recovered vary according to the variety of paddy, its age and moisture content, and the degree of milling and polishing. When the extent of milling is relatively large, as in machine milling, the proportion of bran removed increases with a corresponding reduction in the output of rice. The average recovery of rice (including broken grains) from paddy by different milling processes is as follows: home-pounding, 70-73; huller type mills, 68-69; and sheller type mills, 69-70%. Though home-pounding generally gives a better recovery of rice, the proportion of broken grains is higher than that found in machine-milled rice. The type of machinery used also influences the out-turn of rice; the automatic sheller causes less breakage than the hullers.

The milling quality of paddy is stated to be adversely affected if the crop is harvested over-ripe. Parboiling toughens the kernel and minimizes breakage during hulling; also comparatively less bran is removed and consequently there is a higher recovery of rice including brokens, than on hulling untreated rice. Drying the paddy prior to milling reduces breakage; thus recovery of head rice is greater from old paddy which has a lower moisture content than from new paddy.

Steps have been taken from time to time by the Government of India to control the milling rate for increasing rice supplies and reducing the loss of nutrients during milling. Under the Rice Milling Industry (Regulation) Act of May 1958, licensees of mills shall not remove more than 5% or less than 3% of bran, except under certain conditions. Removal of bran to the extent of c. 3% is essential; otherwise rice deteriorates rapidly on storage, has unattractive appearance, and causes digestive troubles. Excessive removal of bran beyond 5% divests rice of its valuable nutrients. The degree of milling in home-pounding generally does not exceed 5%, whereas in mechanized sector, over-milling is common. Home-pounded (or undermilled) rice has, therefore, a higher nutritive value (*Rep. Marketing Rice*, 1954, 165-69; *Rice Economy of India*, 36, 38).

Considerable discussion has taken place regarding the comparative merits of hand-pounding against milling. The Rice Milling Committee appointed by the Government of India in 1954, while reaffirming the advantages of hand-pounding in terms of rural employment, larger hulling returns, better nutritive product and recovery of pure bran, recognized the utility of rice mills in providing rice with more attractive appearance and cheaper in price (*Rice Economy of India*, 35-37).

EFFECT OF STORAGE AND PROCESSING ON COMPOSITION

Storage Paddy keeps almost indefinitely, provided it has been dried (moisture, <9%) and stored in a dry place. If it gets wet during harvesting or threshing and is stored in godowns as such, it acquires a dull colour as a result of microbial processes. The rice from such paddy (called *zaphrani* in commerce) is yellow or brown in colour. Highly discoloured rice becomes bitter and produces digestive disorders; some samples are reported to be even toxic. Investigations on a sample of yellow rice obtained from a bulk godown indicated that there was a deterioration

in the nutritive value of the protein, though the thiamine content was unaffected. Since hot and humid conditions of storage are conducive to the development of microbes, paddy should be well-dried before storage in bulk godowns and warehouses; there should also be a proper ventilation during storage (*Rep. Marketing Rice*, 1954, 250-51; Ghose *et al.*, 398).

Home-pounded and undermilled rice have a short storage life owing to the high content of fat in the bran which develops rancidity and imparts an unpleasant odour and taste to the whole grain. During milling, the oil-bearing bran gets mostly removed, hence white rice keeps for longer periods. Storage lives of the different kinds of rice as estimated by plotting the peroxide values of the fat against the storage period in conjunction with organoleptic tests, were found to be: raw husked rice, 7; raw undermilled rice (7% milling), 12; and raw milled rice (14-15% milling), 13 months. Parboiled rice is generally found to discolour on storage, due perhaps to the greater moisture content of the grain resulting from insufficient drying after steeping. And as the bulk of parboiled rice production in India is centred round places of heavy rainfall and humid conditions, there is a greater tendency for discolouration. Parboiled rice is, therefore, stored for as short a time as possible (*Rep. Marketing Rice*, 1954, 250-51; Rao *et al.*, *J. Sci. Fd Agric.*, 1954, 5, 405).

Under similar conditions of storage, the damage due to insect infestation is likely to be greater in husked and home-pounded rice than in parboiled or raw milled rice. The hard, glassy surface of the parboiled grain affords a poor grip for the mandibles of the insect pests. Infestation of the rice grain increases the loss of starch in the gruel during cooking, the loss being maximum in the case of husked rice. White cooking, more breakage occurs in the infested husked rice than in the case of undermilled and milled rice samples. Organoleptic tests showed that husked rice infested for periods of four months or more was unacceptable due to off-flavour and slight bitterness, while the other types were found to be acceptable even up to 6-8 months after infestation (*Subrahmanyam et al., Bull. cent. Fd technol. Res. Inst., Mysore*, 1955-56, 5, 329; *Rep. Marketing Rice*, 1954, 251).

Rice from freshly harvested paddy has poor cooking qualities as compared to rice from paddy stored for about a period of 6 months after harvest. It cooks to a glutinous mass, has low swelling capacity during

cooking, and is reported to cause digestive disorders. The pastiness on cooking of fresh rice is attributed to its high α -amylase content or colloidal properties. Well-stored grains swell on cooking to about four times the original volume while the grains from freshly harvested paddy hardly swell to twice the original volume. The properly swollen grains present a greater reactive surface and are thus better penetrated by the digestive ferments. Storage of rice in gunny bags for one year at room temperature (22–33°) showed that the maximum improvement in cooking quality was effected in the raw milled rice and least in the husked rice. Though milling is found to enhance the cooking quality of both unstored and stored rice, excessive degree of polishing of the stored product results in a reduced swelling capacity. The optimum period of storage for rice varies widely owing to the diversities of consumer preference and the variability of the time and methods adopted to cook this cereal. It is also dependent on the harvesting practices. Drying of paddy grains followed by hermetic storage is reported to be an effective method of storing (Sreenivasan, *Indian J. agric. Sci.*, 1939, **9**, 208; Rao *et al.*, *J. Sci. Fd Agric.*, 1954, **5**, 405; *Rep. Marketing Rice*, 1954, 250–51; Grist, 295–96).

Chemical changes in rice under varying conditions of storage have not been studied in detail. On storage of raw rice in gunny bags at room temperature, a decrease in nitrogen soluble in 3% NaCl (probably due to the denaturation of protein) has been observed, while total nitrogen remained practically constant. There has been also an increase in the acidity and peroxide value of the fat present in the different samples, the values being lowest for raw milled rice. In another experiment, it has been found that during storage, the amount of carbohydrate constituents did not change much. In the first three months after harvest, there is a gradual reduction in α -amylase activity, accompanied by certain physico-chemical changes in the colloidal state of starch. The inactivation of the starch-liquefying α -amylase during storage is considered responsible for the improvement in swelling capacity during cooking (*Rep. Marketing Rice*, 1954, 250–51; Rao *et al.*, *J. Sci. Fd Agric.*, 1954, **5**, 405; Sreenivasan, *Indian J. agric. Sci.*, 1939, **9**, 208).

Considerable losses of B-vitamins occur in raw rice during storage at room temperature. The losses are much less in the case of parboiled rice. Cold storage of raw rice for 30 months did not cause any significant loss of the vitamins, whereas the average losses in husked and milled rice stored at room temperature

for the same period were respectively as follows: thiamine, 25, 30; riboflavin, 4.2, 5.5; and nicotinic acid, 3.9, 3.8% (*FAO nutr. Stud.*, No. 1, 1954, 25–26; Rao *et al.*, *J. Sci. Fd Agric.*, 1954, **5**, 405; Subrahmanyam *et al.*, *Bull. cent. Fd technol. Res. Inst., Mysore*, 1955–56, **5**, 329).

A simple process for curing fresh rice to improve its cooking quality (without resorting to storage), both for domestic and commercial use, has been developed at the Central Food Technological Research Institute, Mysore. The method employs the principle of wet-heat conditioning which imparts hardness to the grain, so that disintegration of starch granules in the cooking water leading to pastiness is prevented. In the domestic curing method, the soaked raw rice is steamed for c. 10 min. immediately prior to cooking. A simple rice cooker where the steaming and the subsequent cooking could be done in the same vessel has been devised. In the commercial curing method, fresh paddy after steaming for c. 15 min. is kept hot in a heap for about an hour. It is then dried by aeration preferably in the shade or mild sun before being milled. As the paddy is not soaked in water prior to steaming, complete gelatinization of the starch leading to translucency and yellow colour, characteristic of parboiled rice does not occur. The rice from cured paddy is opaque and has the appearance and cooking qualities of the stored product. The steaming treatment also induces a certain amount of vitamin penetration into the grain and hence the cured rice, like the parboiled rice, is richer in thiamine content than the untreated rice (Rao, *Curr. Sci.*, 1937–38, **6**, 446; Desikachar & Subrahmanyam, *J. sci. industr. Res.*, 1957, **16A**, 365, 368; *Res. & Ind.*, 1958, **3**, 245; Ghose *et al.*, 391–92).

Milling—The concentration of vitamins, minerals, and proteins in the germ and the outer layers leads to a very considerable loss of the nutrients during the conversion of paddy to white or polished rice. The amounts of nutrients removed depend upon the degree of milling and rice is milled often to the extent of as high as 15% to ensure an attractive appearance and good cooking and keeping qualities. Losses of nutrients resulting from milling can be seen from the values given in Tables 15, 16 and 18; approximate losses of important nutrients are as follows: protein, 15; fat, 8.5; calcium, 90; thiamine, 80; riboflavin, 70; niacin, 68; pantothenic acid, 62; and pyridoxine, 56%. Another effect of milling is that the removal of the protecting seed coat facilitates the extraction of soluble substances from the aleurone

layer during washing immediately before cooking the grain (Ghose *et al.*, 394; FAO *nutr. Stud.*, No. 1, 1954, 18-19).

The loss of thiamine due to milling is particularly significant. In countries where rice is the most important ingredient of the diet, the continuous and exclusive use of white rice causes in beriberi, a deficiency disease which arises from abnormally low thiamine intake. The disease is more prevalent among breast-fed infants and in its acute form often leads to their sudden death. It can be effectively treated by administering thiamine. Other deficiency diseases such as keratomalacia, stomatitis, glossitis, cheilosis, and burning feet are reported to occur much more frequently among rice eaters than among wheat eating populations in general (FAO *nutr. Stud.*, No. 1, 1954, 9-10).

Washing & Cooking -Rice is usually washed before cooking to remove dust, insects and husk, and also the fine starch particles adhering to the grains which, if left, cause stickiness in the cooked rice. Washing results in extraction of some of the water soluble nutrients from the grain, the amount removed depending on the degree of milling and intensity of washing which vary from place to place. Husked rice with the seed coat intact is less impoverished than the hand-pounded or milled rice. The losses of B-vitamins occurring during washing of husked and milled rice are respectively as follows: thiamine, 21.1, 43.0; riboflavin, 7.7, 25.9; and niacin, 13.0, 23.0%. Experiments in India showed that as much as 55% of thiamine in raw milled rice was lost on intensive washing; loss of thiamine in parboiled milled rice was only 9%. Minerals are also depleted to a considerable extent during washing; about 56% of iron is removed from milled rice. Parboiled rice is reported to lose major part of its calcium content during washing, but there is practically no loss from husked and milled rice.

The depletion of nutrients during cooking is generally less serious than due to washing. Common method of cooking which uses excess water that is subsequently discarded, causes the maximum loss. It was found that 25-33% of the thiamine present in the washed milled rice was removed by cooking in this manner as is commonly practised in India. In another investigation, the thiamine content of raw rice ranged from 2.67 to 4.30 $\mu\text{g}/\text{g}$; the corresponding value after cooking was 1.05-1.17 $\mu\text{g}/\text{g}$. Cooking brown rice in open vessels is reported to involve the following losses: thiamine, 32.2; riboflavin, 26; and

nicotinic acid, 31%; cooking in a double boiler leads only to a small loss (FAO *nutr. Stud.*, No. 1, 1954, 20-22, 68-69; Swaminathan, *Indian J. med. Res.*, 1942, 30, 409; Ahmad *et al.*, *Ann. Biochem.*, 1948, 8, 89).

Thus, drastic washing of rice and discarding the water after cooking lead to serious loss of nutrients. Only 15% of the thiamine present in one of the samples of milled rice was retained after washing and cooking. The combined losses resulting from the washing and cooking methods commonly used in India are as follows: protein, 10; iron, 75; and calcium and phosphorus, 50%. The losses can be minimized by limited washing and suitable cooking methods. The excess water which is drained off after cooking contains vitamins, minerals, amino acids, sugars and gelatinized starch. It can be used for thickening of soups and in puddings, or can be consumed as such after flavouring or mixing with buttermilk (FAO *nutr. Stud.*, No. 1, 1954, 22; Aykroyd *et al.*, *Indian med. Res. Mem.*, No. 32, 1940, 29-30; *Bull. cent. Fd technol. Res. Inst., Mysore*, 1953-54, 3, 142).

The development of practical methods for retaining the nutrients, particularly vitamins of the B group, in the milled rice has received much attention in the recent past. The problem has been approached either by undermilling of rice, i.e. removing less of the outer layers and germ in milling, or by processing the rice prior to milling in such a way as to cause penetration of the vitamins and other water-soluble nutrients present in the outer layers of the grain into the endosperm. It has been suggested that the minimum thiamine content of milled rice should be 1.5-1.8 $\mu\text{g}/\text{g}$. to ensure that rice as finally consumed will not be dangerously poor in this important vitamin.

The use of home-pounded or undermilled rice in place of highly milled rice has been advocated on nutritional grounds as well as to increase the yield of head rice. The use of milled rice has, however, increased, due to the fact that the rice eaters generally prefer the taste and attractive appearance of milled rice. Both home-pounded and undermilled rice have poorer keeping qualities than milled rice (Narayanswami, 68).

To remedy the deficiencies of white rice, enrichment processes are advocated. This involves the preparation of a fortified premix which is added in appropriate amounts to untreated milled rice. The premix is prepared by impregnating a batch of the

milled rice with a solution of the required vitamins and minerals in suitable concentrations. The impregnated grains are dried, mixed with finely ground iron pyrophosphate, and then sprayed with an alcoholic solution of zein and fatty acids. This solution, after drying, provides a coating (insoluble in cold water but soluble in hot, i.e. cooking water) which protects the enriching ingredients against deterioration and depletion during washing preparatory to cooking. The premix is blended with white rice in the ratio of approximately 1:200 and the enriched rice so obtained has the nutrient content equivalent to that of husked rice. The appearance, flavour and cooking quality of rice are not affected by enrichment. Studies have shown that the rice premix has good resistance to washing, cooking, and storage losses (Jacobs, II, 1087-89; FAO *nutr. Stud.*, No. 1, 1954, 27-37; Grist, 340-45).

UTILIZATION

Rice is the staple diet of over a third of the world's population and is consumed principally in Asia. It is a starch-rich food, cooked by boiling in water and eaten mostly with cooked pulses, vegetables, fish or meat. Several types of dishes are prepared from rice flavoured with spices and other ingredients. It is also converted into preparations such as parched rice, beaten rice or rice flakes and puffed rice. Mixed with black gram, it is used for making fermented preparations like *idli* and *dosa*, popular in South India.

Paddy is used to a limited extent for feeding livestock. Broken grains obtained during milling are used as human and cattle food, in making alcoholic beverages, and as a source of starch and flour. In India, they are used mainly for human consumption, only small quantities being utilized, along with inferior rice, for feeding animals. Rice flour is used in confectionery, ice creams, puddings and pastry and in cosmetics. Rice starch, besides being used for food and laundering purposes, finds several applications in industry. Because of the shortage of rice and its high prices, only small quantities are used in India for non-food industrial purposes. It is estimated that of the total quantity of rice produced in India, c. 89% is used for the table, c. 4.5% for making parched rice and beaten rice, c. 0.5% for feed and non-food industries, and c. 6% for seed (Rice Economy of India, 42, 45; Jacobs, II, 1090; Brautlech, 262; Grist, 322).

Paddy husk is utilized mainly as fuel. It may be used in building material, for making hardboard, and

as a raw material for alcohol and furfural. The bran serves as a valuable cattle feed. The fatty oil extracted from the bran is used for edible purposes. Rice straw is employed as fodder in many parts of India. It is suitable for the manufacture of strawboards (Rice Economy of India, 43; Grist, 324-26).

RICE PRODUCTS

The most common rice products on the Indian market are Parched rice, Parched paddy and Rice flakes, which are prepared mainly on cottage industry basis. The quantity of rice used for the manufacture of these products in India is estimated at 4.5% of the total supplies of rice, but exact data are not available. Uttar Pradesh is the largest producer of rice products in the country; large quantities are manufactured also in West Bengal, Madhya Pradesh, Bihar and Orissa. A certain amount of internal movement takes place from West Bengal to Bihar and Orissa, and from Uttar Pradesh to Punjab, Delhi, Madhya Pradesh and Rajasthan (*Rep. Marketing Rice*, 1954, 328-31, 340-46).

Parched rice (HINDI—*Murmura*; BENG.—*Murice*; GUJ.—*Mumra*; TEL.—*Murmuralu*; TAM.—*Arisipori, mottupori*)—Parboiled rice is preferred for making *murmura*. The parching operation is a simple one, there being small variations in the methods adopted in different areas. Sand in an iron pan (or open earthen vessel) is heated to a high temperature over fire. Three or more handfuls of rice are then thrown in and rapidly stirred into the hot sand. As soon as the rice begins to crackle and swell, the contents of the pan are removed and passed through a sieve to separate the parched rice from sand. In West Bengal, prior to parching in sand, rice is fried in an iron pan with frequent sprinkling of salt water. A preparation known as *bhunja* is made in Bihar and Orissa from unsalted parboiled rice in the same way as the parched rice of West Bengal. In Madhya Pradesh, rice is steeped for several hours in a dilute salt solution, dried, and then parched in sand in the usual way. In Madras, salting is done in one, two or three doses depending upon local requirements. Parched rice is generally sifted to remove the insufficiently expanded grains, which are subsequently ground into flour (*sattu*) in a hand stonemill (*chakki*); *sattu* has some demand in northern India, during summer months.

Parched rice is a distended, crisp product, with a greyish to a brilliant white colour and is sold either salted or unsalted. Well distended, white grains fetch

the best price. The yield of parched rice is 85–90% from parboiled rice and c. 58.5% from paddy. Mixed with buttermilk or milk, it is a ready-to-serve food and is reputed for its easy digestibility [*Rep. Marketing Rice*, 1954, 331–32; Palaniswamy & Chandra Mohan, *Indian Eng.*, N.S., 1963–64, 13(12), 19].

Parched paddy (HINDI—*Kheel*; BENG.—*Khai*; GUJ.—*Churmura*; TEL.—*Vadlapelalu*; TAM. & MAL.—*Nelpori*)—For the preparation of *kheel*, the paddy is dried in the sun and towards evening filled in earthen jars. The paddy is then moistened by adding hot water which is decanted off after 2–3 min. The jars are then kept overnight in an inverted position. Next morning, the paddy is exposed to the sun for a short period, after which it is kneaded while still moist, and then parched in hot sand in the same manner as in the preparation of parched rice. During the parching process, the grains swell and burst into a soft white product. The parched grains are sieved to remove the sand and finally winnowed to separate the husk. The average recovery of *kheel* from paddy is reported to be 61%.

A similar type of preparation, known as puffed or popped rice, is a popular breakfast food in the U.S.A. It is made by placing rice in sealed containers and

heating for an hour at 550°; the moisture in the grain is converted into steam and when the pressure is suddenly released, the steam expands the grains, puffing them to several times their original size.

Flaked rice (HINDI—*Chura*; BENG.—*Cheera*; GUJ.—*Poua*; TEL.—*Atukulu*; TAM. & MAL.—*Aval*)—It is a type of parboiled rice made flat and thin by pressure. In the traditional method of preparation, paddy is soaked in water for 2–3 days to soften the kernel, followed by boiling in water for a few minutes. After cooling, the water is drained off and the paddy is then heated in a shallow earthen vessel or iron pan till the husk bursts open, after which it is pounded by a wooden pestle which flattens the rice kernel and removes the husk. The husk is separated by winnowing. The average out-turn of flaked rice from paddy is 64.5%. In the mechanized process, roller devices are employed for flattening the gelatinized rice grains; the pressure applied is sufficient to obtain very thin flakes.

Flaked rice is thin and papery and of white colour; large, broad flakes are generally preferred. Flaked rice prepared by traditional method is equivalent to parboiled rice in vitamin values. It can be stored for several months without deterioration. It is commercially more important than *Murmura* or *Kheel*. Rice flakes, improved by the addition of suitable flavouring and sweetening agents, could compete with corn flakes as a breakfast food.

Other preparations from rice include vermicelli, *papad*, and curls which are made from rice flour or a mixture of rice flour and black gram flour. Methods for the preparation of 'Instant Rice' have been developed at the Central Food Technological Research Institute, Mysore, and the Defence Science Laboratory, New Delhi. Such precooked rice is likely to be of value for specialized purposes and under conditions of emergency (Ghose *et al.*, 387–88; Brautlecht, 261–62; *Rep. Marketing Rice*, 1954, 332–33).

Rice starch—The broken grains are generally used for the manufacture of rice starch. In India, only rice flour is prepared to a negligible extent from broken rice or bold coarse rice. The main difficulty in starch extraction is the separation of gluten from starch granules. Caustic soda is commonly employed for making the protein soluble. Cleaned rice is soaked in dilute caustic soda solution in large steel or concrete tanks, with perforated false bottom. After a soaking interval, the steep liquor is run off and the steeping repeated three times or so till the rice kernels are soft enough to crush between fingers;



Indian Coun. Agric. Res., New Delhi
FIG. 68—PREPARING PARCHED PADDY

steeping is usually completed in 18–24 hr. The steeped grains are washed with water and ground in stone mills to a wet pulp of c. 25% total solids. A dilute caustic soda solution is usually added during grinding to aid in removing the gluten. The starch slurry is sifted and the starch separated from the protein liquor by sedimentation, centrifugation or filtration; rice starch slurry is not generally tabled due to the slow settling rate of the small granules. Chemicals such as sodium hydroxide, sulphur dioxide or formaldehyde solution are often added to inhibit fermentation in the starch slurry and to obtain a pure white product. The protein liquor can be precipitated, filtered and dried for use as feed or fertilizer (*Bull. Imp. Inst., Lond.*, 1918, 16, 16).

The starch is purified by repeated washing and is centrifuged to obtain a product with c. 40% moisture content. The moist starch is drained or moulded into cubes in filter boxes or presses, and partially dried on crusting ovens. The yellow crust of impurities which forms on the surface is scraped off and drying is then continued to obtain the desired moisture content. For making 'crystal' starch, the blocks are wrapped in paper and dried slowly for 2–3 weeks in an oven; when cooled and tapped lightly, the starch blocks break into crystals containing 12–15% moisture. The yield of starch is 85–90% of that present in the grains.

Rice starch is marketed in the form of crystals, lump or powder. It is pinkish white in colour with a pleasant odour and has a gelatinization temperature of 75°. Commercial starch contains: moisture, 10.07–11.95; ash, 0.28–0.65; fat, 0.45–0.87; and protein, 0.14–0.56%. The granules of rice starch have the smallest size (diam., 3–5 μ) among the ordinary starches (*Rep. Marketing Rice*, 1954, 331; Brautlecht, 262–70; Radley, II, 27–29, 328, 341; Bhatti & Wahhab, *Pakist. J. Sci.*, 1957, 9, 209).

Rice starch is used as food, especially in puddings, ice cream, pies and custard powders. Its principal use, however, is as a fine, stiffening laundry starch and for this purpose, it is often preferred to other starches. It finds use also as a cosmetic in face and dusting powders, as a thickener in calico printing, in the finishing of textiles, and for making dextrin, glucose and adhesives. It is also used as a diluent for alkaloid-containing preparations and as a disintegrant for pills and tablets (Brautlecht, 271; Bhatti & Wahhab, loc. cit.; Hoppe, 627; U.S.D., 1955, 1311).

Alcoholic beverages Rice is widely employed for the manufacture of beers, wines and spirits in Japan, China and other eastern countries. Such

rice-based beverages are, however, not popular in India. For their manufacture, cultures of certain fungi in association with yeast are used. For the preparation of the well-known Japanese national drink, *saki*, the fungus used is *Aspergillus oryzae*; elsewhere *Mucor* spp. seem to be the most important (Grist, 323).

BY-PRODUCTS

Bran—The bran is the most important by-product of the rice milling industry and is valued as a cattle feed; it also yields an edible oil. It comprises the germ, the pericarp, and aleurone layer and is often found mixed with varying quantities of husk. The extent of recovery of the bran depends upon the process of husking and the degree of polishing. Under the Rice Milling Industry (Regulation) Act of May 1958, the mills in the country have been directed not to remove more than 5% bran on the weight of paddy. Earlier enquiries from Madras State had revealed that the production of the bran under the single polish conditions varied from 10 to 15% on the weight of paddy. The sheller type of mills produce a fairly clean bran free from husk, but in the huller type of milling, the husk gets finely crushed and is generally not separated from the bran; the bran obtained in the first stage of hand-pounding also gets mixed with husk. Though, the total quantity of the bran recoverable in India is theoretically over 2 million tonnes (assuming that bran recovery is 5%), the actual production of bran unadulterated with husk is much less (*Rice Economy of India*, 43, 38; *Rep. Marketing Rice*, 1954, 348).

The chemical composition of rice bran varies with the method and extent of milling. The bran from shellers is high in oil and protein contents, and low in ash and silica. Owing to the presence of high proportion of husk, the bran from hullers is coarse in texture, with comparatively lower oil and higher ash and silica contents. The protein content in the bran from hullers is only about two-thirds of that present in the bran from sheller. The average oil content in both parboiled and raw rice brans from shellers is double that present in those from the hullers. Analysis of the bran gave the following ranges of values: moisture 8.9–12.5; fat, 10.6–22.4; protein, 10.6–14.8; N-free extr., 38.7–44.3; fibre, 9.6–14.1; and ash, 9.3–15.0%. The bran contains sucrose (3–5%) and reducing sugars (1.3%). It is rich in thiamine and nicotinic acid (Table 18) and its proteins are superior to those of the rice kernel.

(Table 17). The mineral content of the bran is as follows: calcium, 0.13; phosphorus, 2.39; potassium, 0.14; sodium, 0.24; magnesium, 0.14; and silica, 4.07%. Iron (224 p.p.m.), aluminium, copper, manganese, tin and chlorine are also present [Rao & Murti, *Indian Oilseeds J.*, 1961, **5**, 121; Kumar David *et al.*, *ibid.*, 1964, **8**, 49; Rao, *Indian Fd Packer*, 1958, 12(6), 6; Lander, appx III; Rao & Krishnamurthy, *Indian Oilseeds J.*, 1958, **2**(2), 104].

Rice bran free from husk has a high nutritive value (Table 20) and is used mainly as a feed for cattle. Bran obtained from huller type of mills is not safe as cattle feed; it is reported to cause digestive disorders in animals. Rice bran supplies almost the same amount of protein as wheat and oats, and its protein is of considerably better quality than maize. It is stated to be used even as human food, particularly as a remedy against beriberi. It is fairly palatable when fresh, but often turns rancid on storage. The bran from milling of raw rice is stated to be nutritionally superior to that from parboiled rice. Feeding of the bran to dairy cattle increases milk yield, but it should form not more than 30% of the ration; excessive amounts produce a soft butter. When it constitutes over 30% of the ration for pigs, the bran produces a soft pork and may also cause a serious purging in animals. It can be used as a substitute for wheat bran or middlings in poultry feeding (Ramiah, 94; Morrison, 457-58; Ghose *et al.*, 384).

TABLE 20—FEEDING VALUE OF RICE PRODUCTS*

	Dry matter %	Protein %	Digestible protein %	Total digestible nutrients %	Nutritive ratio
Paddy	88.8	7.9	6.0	70.2	10.7
Husked rice	87.8	9.1	7.0	81.0	10.6
Polished rice	87.8	7.4	5.7	80.1	13.1
Paddy husk	92.0	3.0	0.1	9.9	98.0
Rice polish	89.8	12.8	9.7	81.5	7.4
Rice bran†	89.0	9.3	6.1	54.5	8.3
Rice bran, solvent extracted	90.9	14.3	9.7	55.3	4.7
Rice straw†	93.0	3.4	0.2	39.0	243.5

* Morrison, 1014, 1062.

† Lander, appx I.

Rice bran or its aqueous extract exhibits a protective action against experimental polyneuritis in chickens. It is stated to be an effective larvicide against mosquito larvae. Studies in Japan have resulted in the isolation of three substances from the bran which are useful in skin diseases. Old or damaged bran is used as manure (Murti & Rao, *Indian Oilseeds J.*, 1956-57, **1**, 91; *Chem. Abstr.*, 1960, **54**, 23208; *Rice Economy of India*, 43).

Bran oil—The bran contains up to 25% of a fatty oil used for edible and other purposes. The oil is extracted in large quantities in Japan and to a lesser extent in the U.S.A. In India, rice bran oil industry has made rapid strides during the recent years; 15 solvent extraction plants are reported to be operating in different parts of the country. Most of the plants are located in Andhra Pradesh, Maharashtra, Mysore, Uttar Pradesh and West Bengal. Steps are being taken by the Government of India to encourage the setting up of solvent extraction plants in the main milling areas. India produces nearly one million tonne of bran, which can be used to yield about 150,000 tonnes of oil. The main problems involved in the development of rice bran oil industry are the collection of a suitable quantity of bran and its transport and storage prior to extraction. The bran from shellers is best suited for the extraction of oil. The bran from hullers contains a high proportion of husk which is rather difficult to remove; it can be upgraded by pneumatic separation or sieving (*Rice Economy of India*, 43-44; Narayana *et al.*, *Bull. Oil Technol. Ass. India*, Annu. No., 1963, 26; Kumar David *et al.*, loc. cit.; Rao & Murti, *Indian Oilseeds J.*, 1961, **5**, 121; Zachariassen & Giasotta, *Chem. Age, India*, 1964, **15**, 194; Reddy, *J. Ind. & Tr.*, 1965, **15**, 1208).

Examination of several samples of bran from different rice mills showed that the oil content generally ranged from 17 to 22%; bran from raw rice contained 13.9-24.1% and from parboiled rice, 12.1-26.5% of oil. The bran should be extracted soon after it is milled, otherwise it deteriorates quickly; an extremely active lipase begins to act as soon as the bran is removed from rice and causes free fatty acid in the oil to increase rapidly, at the rate of 1% per hour during the first few hours of the storage of the bran. Storage experiments carried out at the Oil Technological Institute, Anantapur, revealed that the free fatty acid in the oil rose from 3% in the fresh bran to 62.5% after 100 days. Heating of the bran immediately after it is milled, at about 100° for a period of 2 hr. is found to inactivate the lipolytic

enzyme system and increase the storage life of the bran considerably. Oils with high acidity are difficult to refine and bleach to edible grades [Rao & Krishnamurthy, *Indian Oilseeds J.*, 1958, **2**(2), 104; Murti & Rao, *ibid.*, 1956-57, **1**, 91; Kumar David *et al.*, loc. cit.; Rao & Krishnamurthy, *Bull. cent. Fd technol. Res. Inst., Mysore*, 1954-55, **4**, 205].

The oil is obtained from the bran by expression in hydraulic presses or extraction with solvents. Hydraulic presses recover only c. 50% of the oil in the bran. Solvent extraction is the most promising method, and hexane is the solvent commonly used. The yield of oil varies according to the source and quality of bran, the solvent used and the temperature of extraction. The average oil yield from the Indian rice bran is reported to be 12-14%. The crude oil is green in colour owing to the presence of chlorophyll (up to c. 20 p.p.m.); it also contains considerable quantities of wax, on an average 3% in oils from parboiled rice bran and 9% in oils from raw rice bran. On allowing the crude oil to stand or wintering it at 20-25°, the wax settles out and can be removed by centrifuging or filtering. The oil can be completely dewaxed by mixing with acetone, cooling to 10°, and centrifuging the precipitate. The dewaxed oil can be refined (using 10% alkali) and bleached (using acid clay) in the usual way to obtain an edible grade oil. The refining losses amount to 15% with oils containing c. 3% free fatty acids. Prior treatment of the crude oils with additives such as sodium pyrophosphate, sodium silicate, jaggery and sugarcane molasses is found to reduce refining losses considerably [Murti & Rao, *Indian Oilseeds J.*, 1956-57, **1**, 91; Kumar David *et al.*, loc. cit.; Meinke *et al.*, *J. Amer. Oil Chem. Soc.*, 1949, **26**, 532; Warth, 237; Rao, *Oils & Oilseeds J.*, 1954-55, **7**(9), 14; Rao & Murti, *Indian Oilseeds J.*, 1961, **5**, 121; Rao & Krishnamurthy, *ibid.*, 1958, **2**(2), 104; Narayana *et al.*, loc. cit.].

A modified process using industrial or absolute alcohol for the extraction of bran oil has been developed at the Central Food Technological Research Institute, Mysore. Hot alcohol extracts oil from the bran and the extract is cooled to obtain a high grade oil. The yield of refined oil is 76-79% of the oil originally present in the bran. This process is more economical than the hexane extraction process because refining loss of oil is reduced and more by-products are recovered. The by-products obtained in this process include wax, fatty acids, sugar syrup rich in B-vitamins, bran meal which still retains half to two-thirds of the B-vitamins originally present in the

meal, and soap stock (Rao & Krishnamurthy, *Bull. cent. Fd technol. Res. Inst., Mysore*, 1954-55, **4**, 205; *Res. & Ind.*, 1956, **1**, 87).

The refined oil is pale green in colour and possesses a good flavour. The characteristics of the oil are as follows: sp. gr.^{20/40}, 0.916-0.921; n_{D}^{25} , 1.470-1.473; n_{D}^{40} , 1.465-1.468; titre, 24-28°; iod. val., 99-108; sap. val., 181-189; acid val., 4-120; thiocyanogen val., 69-76; hydroxyl val., 5-14; R.M. val., <0.5; Polenske val., <0.5; Ichner val., 95.3; and unsaponifiable matter, 3-5%. The composition of fatty acids is as follows: myristic, 0.4-1; palmitic, 13-18; stearic, 1-3; oleic, 40-50; linoleic, 29-42; and linolenic, 0-1%. Presence of small amounts of arachidic, lignoceric and behenic acids is reported in some samples. The refractive index of the oil is higher than that of most other oils having about the same iodine and saponification values; this is possibly due to the unsaponifiable matter which has a high refractive index and contains squalene (202-489.6 mg./100 g. oil). Tocopherols (c. 0.1% in the oil), sitosterol, and stigmasterol are reported in the unsaponifiable matter. A substance (m.p. 95.3°) similar to calciferol has been recently reported in the oil [Rao & Krishnamurthy, *Bull. cent. Fd technol. Res. Inst., Mysore*, 1954-55, **4**, 205; Eckey, 295-96; McCall *et al.*, *Bur. agric. industr. Chem., U.S. Dep. Agric.*, AIC-312, 1951, 17-18; Warth, 237; Kumar David *et al.*, loc. cit.; Rao, *Oils & Oilseeds J.*, 1954-55, **7**(9), 14; *Chem. Abstr.*, 1963, **59**, 1711].

Rice bran oil is as good an edible oil as refined groundnut and cottonseed oils, and has better keeping qualities due to the presence of antioxidants (α - and γ -tocopherols). It is suitable for use as a salad and cooking oil and in the preparation of shortenings and vanaspati (hydrogenated oil). It is used at present in India for making soaps, oleins and stearins. The oil may be polymerized and sulphonated for industrial uses such as textile and leather treatment. The oil boiled for 3 hr. at 200-230° can be modified with maleic anhydride to give a varnish composition producing flexible films. Single bodied rice bran oil on treatment with oil soluble phenolic resin, as well as with CNSL resin, yields quick-drying surface coating compositions capable of being formulated into enamels. Rice bran oil is reported to prevent cancer in the liver of rats. Tocopherol may be separated from the oil by high vacuum distillation; the oil from pure rice germ is three to four times richer in tocopherol than the bran oil. A process, which involves extraction of the bran lipids with acetone followed by alcohol,

has been worked out at the Central Drug Research Institute, Lucknow, to separate phosphatides, fatty acids, and unsaponifiables containing tocopherols and phytosterols. The extracted bran meal, which keeps well because of low fat and moisture content, is rich in B-vitamins and minerals and is a more palatable feed for the cattle than the bran. It is a useful ration supplement for poultry and pigs. Feeding value of the extracted bran is summarized in Table 20 [Murti & Rao, *Indian Oilseeds J.*, 1956-57, **1**, 91; McCall et al., *Bur. agric. industr. Chem., U.S. Dep. Agric.*, AIC-312, 1951, 19; Rao, *Oils & Oilseeds J.*, 1954-55, **7**(9), 14; Chaudhuri et al., *Paintindia*, 1963-64, **13**(1), 147; Talwalkar et al., *Res. & Ind.*, 1963, **8**, 157; Rao & Krishnamurthy, *Bull. cent. Fd technol. Res. Inst., Mysore*, 1954-55, **4**, 205; Meinke et al., *J. Amer. Oil Chem. Soc.*, 1949, **26**, 532].

Bran wax—The yield of wax recovered as a by-product during the extraction of oil is reported to vary from 3 to 9% on the total oil basis. The crude wax from the settling tanks is generally tan to brown in colour and possesses a good odour reminiscent of crude bran oil. It is soft in consistency and contains only a small proportion of the highly valued hard wax fraction, which can be separated by washing the settling tanks with acetone and subsequent purification by fractionation from isopropanol solution. The hard, non-tacky product, thus obtained, is almost black in colour but can be bleached to a white wax by treatment with hydrogen peroxide followed by chromium trioxide, in the presence of sulphuric acid. It is comparable to Carnauba wax and has the following physico-chemical properties (av. values): m.p., 77.9°; Durometer hardness, 100; iod. val., 15.2; sap. val., 80.7; free fatty acids, 3.8; phosphorus, 0.09; volatile matter, 0.94; and unsapon. matter, 58.1% (Reddi et al., *J. Amer. Oil Chem. Soc.*, 1948, **25**, 206; Cousins et al., *ibid.*, 1953, **30**, 9; Warth, 237-39; Zachariassen & Giasotta, loc. cit.).

The wax consists of esters of waxy acids (C_{22-26} with minor amounts of C_{28-32}) with higher alcohols, mainly myricyl alcohol. The harder fraction is stated to comprise myricyl cerotate (43-44%), ceryl cerotate (21-22%) and isoceryl-isocerotate (9.5-10.5%). The softer wax constituents contain both saturated and unsaturated acids (C_{14-20}). Sitosterol, stigmasterol, phosphatides, squalene and tocopherone are present in the unsaponifiable matter of the wax (Warth, 241).

Rice bran wax is suitable for use in chocolate enrobers, as an enteric coating for candy and lozenges, in the preparation of wax emulsions applied

to fruits and vegetables, as a plasticizing material in chewing gums, as a partial substitute for Carnauba wax in polish emulsions, and as an ingredient in the foundation employed in the manufacture of carbon papers. It can also be used in the manufacture of candles. The bleached wax has a lubricity which favours its use in cosmetics including lipsticks (Warth, 241; Hoppe, 627; *Chem. Abstr.*, 1962, **57**, 17143).

Rice polish—Rice polish is the finely powdered material obtained during polishing of rice grains after the husk and bran have been removed. It does not seem to be recovered in any sizeable quantity in India. Rice polish is comparable to maize in nutritive value (Table 20) and is used for feeding livestock. It is a good source of thiamine and niacin and has the advantage over bran in containing much less fibre (2.7%). It should be fed fresh since it tends to go rancid on storage. Feeding trials have shown that rice polish is satisfactory as part of the concentrate mixture for dairy and beef cattle, swine and sheep. As a swine and cattle feed, it has some of the same limitations as rice bran. Rice polish is reported to promote the regeneration of haemoglobin in albino rats made anaemic by intraperitoneal injection of phenylhydrazine hydrochloride. A concentrate of rice polish has been prepared for use as a supplement to pulses; it is found to increase their protein efficiency ratio and digestibility (Morrison, 458; Chakrabarti et al., *Ann. Biochem.*, 1960, **20**, 299; 1961, **21**, 237).

Rice germ—Rice germ can be isolated from the commercial bran by combined mechanical and pneumatic separation. It is rich in proteins (16-18%) and vitamins and contains 30-37% of oil. The oil can be extracted by hydraulic cold pressing and solvent extraction. It is comparable to wheat germ oil in nutritive value. The defatted germs can be used in dietary formulations in weaning and convalescent food (Rao et al., *Indian Oilseeds J.*, 1960, **4**, 53).

Husk—Paddy husk though produced in large quantities is not of much commercial importance in India. A major part of it is used as fuel (fuel val., 5,000-6,000 B.t.u.) in the boilers of rice mills or in the parboiling equipment; it is rather difficult to burn because of its high ash content. Husk produced by hand-pounding in rural areas is largely used as fuel in households and brick kilns, or is mixed with mud-plaster to improve its binding quality for house building, or is heaped for compost making. Compost prepared from husk is reported to be as good as farmyard manure. The husk has a low feeding value

(Table 20), for it furnishes practically no digestible protein; owing to its high silica content, it is also liable to irritate the digestive tracts of animals. Well-ground husk may replace a part of the roughage in ration of cattle. Analysis of the husk (from Madras) gave the following values: moisture, 8.6; crude protein, 3.1; ether extr., 1.4; N-free extr., 33.5; fibre, 29.7; sol. mineral matter, 2.5; and silica, 21.2%. Silica constitutes up to 96.6% of the total ash [Rice Economy of India, 43; Grist, 324; Morrison, 458; Sen, *Bull. agric. Res. Inst. Pusa*, No. 70, 1917, 41; Rao & Krishnamurthy, *Indian Oilseeds J.*, 1958, 2(2), 104].

The husk can be used in the manufacture of furfural (yield, 9-10%). The high cellulose content of the husk makes it suitable for the production of alcohol, the yield (19-21%) being comparable to that from wood. A pure edible cellulose, useful in raising the roughage content of breakfast foods may be prepared from paddy husk. Charred husk has been utilized as a substitute for bone black in refining sugar. Activated carbon for industrial purposes has been made from the husk. The husk ash, being rich in silica, may find application in the glass industry. The husk has a high abrasive action and is used for polishing rice. It has also been used, in admixture with corncob for soft-grit blasting of carbon and dirt particles from aeroplane pistons and cylinders. Powdered husk is employed as an abrasive ingredient of hard soaps for shop use (Thorpe, II, 496; Grist, 325; Chowdhury *et al.*, *J. Indian chem. Soc., industr. Edn.*, 1947, 10, 40; 1948, 11, 83; Ghose *et al.*, 384).

The husk has been tried with some success as a raw material for making paper, hardboard, rayon and linoleum. The pulp could not be bleached satisfactorily. It finds use in building material. Partly burnt hulls are employed in the making of light weight, low cost bricks. Insulating bricks suitable for use in furnaces have been made with cement and husk ash. A process has been patented for treating husk to render it inert and suitable as aggregate. Pressed insulating board, a high quality cement tile and a cement breeze block can be made from this material (Grist, 324-25; Rice Economy of India, 43).

Straw - Rice straw is largely used for feeding cattle in most of the rice growing tracts in India. Analysis of the straw (from Bangalore) gave the following values: moisture, 7.0; protein, 3.4; fat, 0.9; N-free extr., 47.8; fibre, 33.4; mineral matter, 7.5; calcium, 0.33; phosphorus, 0.06; potassium, 1.26; sodium, 0.35; and magnesium, 0.22%; the content of

digestible nutrients is given in Table 20. Rice straw like other cereal straws is poor in protein, fat, and minerals and has a low digestibility due to the high fibre and lignin contents. Soaking and washing with water, or treatment with sodium hydroxide solution (0.75-1.5%), or boiling with milk of lime (CaO, 1%) for 3 hr. improves the digestibility of rice straw. It is not a maintenance ration and should be fed after supplementing with concentrates such as maize grain, *toria*, or linseed cake, and green fodder. Feeding trials on bullocks with rice straw showed negative balances as regards nitrogen, calcium and phosphorus. The straw can be ensiled to a brown, pleasant smelling product which is readily consumed by cattle (Lander, 166, appx I & III; Morrison, 379; Patel *et al.*, *Indian J. Dairy Sci.*, 1961, 14, 12; Thorpe, II, 497; Grist, 326).

Rice straw is used for the manufacture of strawboards. A sample of the straw contained (on oven-dry basis): cellulose (Cross & Bevan), 53.46; lignin, 25.53; pentosans, 20.99; and ash, 18.58%. For the production of strawboards, digestion of the straw with 12% lime at 142° for 4 hr. gave the best results and the pulps obtained were slightly greenish yellow in colour. Pulps (yield of unbleached pulp 50.2% on oven-dry raw material) suitable for a large range of printing, writing and light wrapping papers can be produced from rice straw. Rice straw is also useful as a source of alcohol (Bhat & Singh, *Indian Pulp Pap.*, 1954-55, 9, 259; Chittenden & Morton, *Colon. Pl. Anim. Prod.*, 1956, 6, 53).

Rice straw is employed for thatching, and making hats, mats, sacks, ropes and baskets. It makes a good litter for brooder houses and is utilized in China for mushroom culture. In Japan, lye made from straw ash and other substances is used for washing hair; taken internally, it is regarded as abortifacient. The straw can be used for composting (Grist, 325-26, 209).

MARKETING AND GRADING

MARKETING

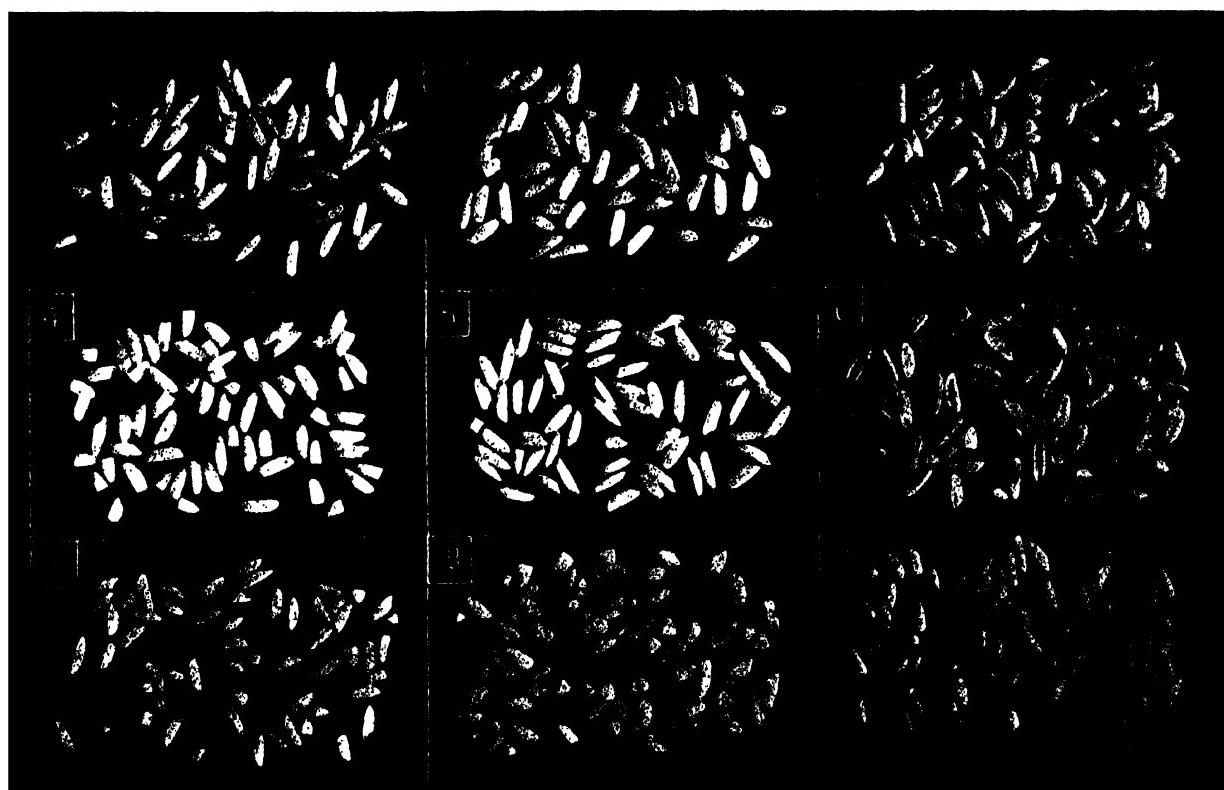
The bulk of the production of rice is retained by producers to meet their own requirements of consumption, seed, payment of wages in kind and so on. The marketable surplus has been estimated at about 1/3 of the total annual production. Taking the different qualities of rice into consideration, the proportion of production put on the market is higher in the case of fine rices as compared to medium and bold rices. Similarly, the bulk of the machine milled rice enters the market, while the bulk of the hand-

pounded rice is consumed by the producers themselves. Again, taking the country as a whole, the marketable surplus of the rice crop is assembled in the forms of paddy and rice in roughly equal proportions. Of the three crops raised in India—winter, summer and autumn—the first one is the most important and the bulk of this crop is marketed between October and April (*Ghose et al.*, 304–05, 311; *Rice Economy of India*, 16, 165–66; *Rep. Marketing Rice*, 1954, 173).

The various agencies concerned in the assembling of paddy and rice, besides the producers, are the village merchants, itinerant merchants, wholesale merchants and professional dehuskers and rice millers. The entire aspect of assembling underwent a temporary change during the period of controls in the war and post-war years, when the Government collected paddy and rice directly or through agents at statutory prices. After the decontrol of rice in July 1954, the normal agencies have been at work again and the main pattern has not appreciably changed (*Rice Economy of India*, 16–18).

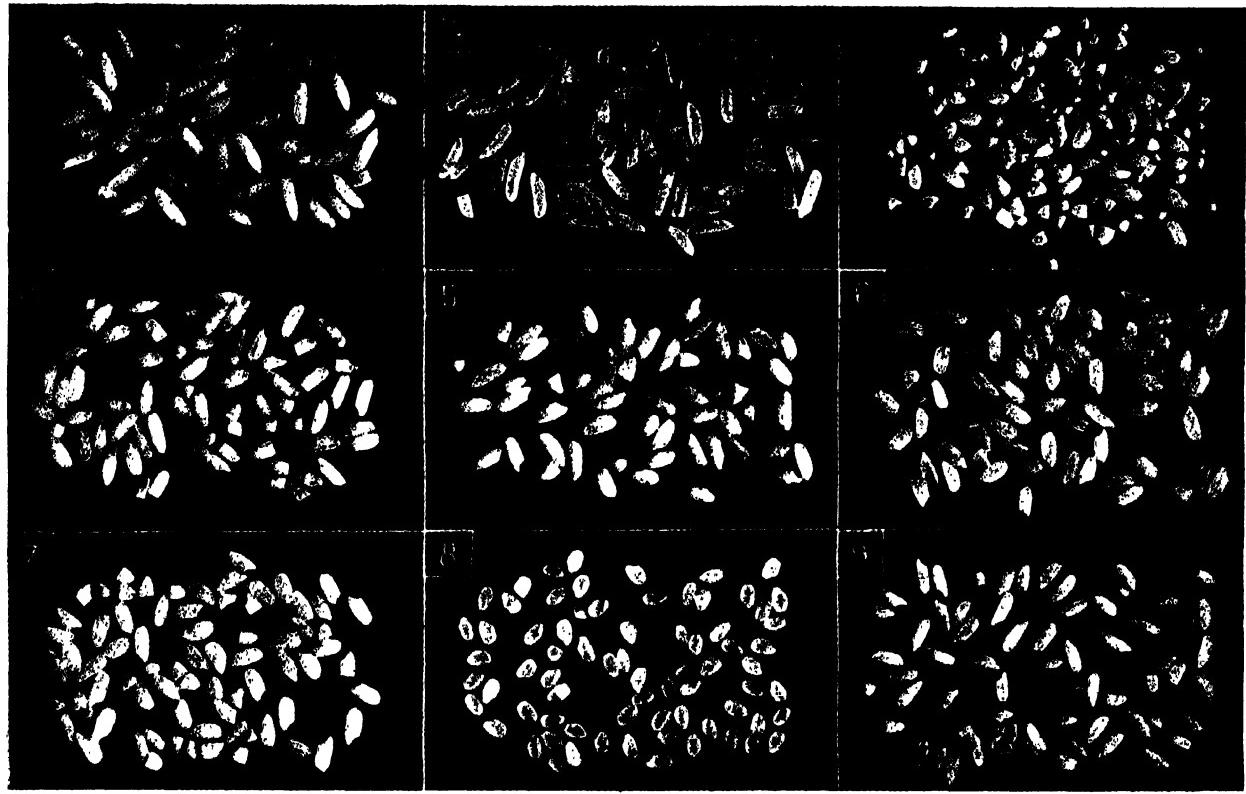
Before it reaches the consumer, rice generally moves through three levels of markets, i.e. the primary markets (*Hatts*), secondary markets (*Mandis*) situated in urban centres, and terminal markets where the produce is finally pooled for consumption or for further distribution in intra- and interstate trade (*Rep. Marketing Rice*, 1954, 182–84).

With a view to ensure better regulation of buying and selling in the wholesale markets, and to safeguard the interests of the producer and seller, statutory regulation of markets has been introduced in the several States under the Agricultural Produce Markets Act and a large number of regulated markets for paddy and rice as well as for other crops have been established in almost all States. The market charges are clearly defined and specified and unauthorized deductions have been prohibited. Further, as an aid to orderly marketing, standard specifications have been drawn up in respect of some well-known commercial types of rice, taking into consideration consumer preference (*Rice Economy of India*, 21–26; *Ghose et al.*, 331–32).



Indian Coun. Agric. Res., New Delhi

FIG. 69—DIFFERENT TYPES OF RICE: 6, PARBOILED; REST RAW RICE



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FIG. 70—DIFFERENT TYPES OF RICE : 1, 2, 4, 8, PARBOILED ; REST RAW RICE

CLASSIFICATION AND GRADING

The trade in rice in this country is based on named types or commercial descriptions of which there is a bewildering multiplicity owing to the enormous number of agricultural types and the wide range of physical variations in the grain due to local agronomic conditions. Various systems of classification have been suggested or adopted in different countries based on grain characters or on a combination of grain and plant characters. The consultative sub-committee of the FAO has also recently published a list of rice terms, which include definitions of different classes proposed as trade grades. In India also, during the war and post-war period, when procurement and distribution of food grains were brought under Government control, paddy and rice were classified in various States according to the prevailing local conditions. But the classification was not uniform in respect to the number of classes recognized and in regard to nomenclature employed. From the marketing point of view, however, the various types and qualities of rice can be included under some broad groups based on dimensions of the

grain, the treatment given to the paddy prior to hulling and the method of milling. Depending upon its conformation, rice is classified as fine, medium and bold or coarse. The fine types have an average length to breadth ratio of well over 3, some having over 3.5 or even 3.75. In the medium types this ratio is generally above 2.5, while in the bold types the tendency is for the ratio to fall below 2.5. This classification into fine, medium and bold based on length/breadth ratio is not absolute but only relative. It has been estimated that fine, medium and bold types formed 13, 32 and 55% respectively, of the total production of rice in the immediate pre-war years, but in the post-war years there is a growing tendency for increased production of bold rice. In the face of acute food shortage, the outweighing consideration has been that of quantity and not of quality; the yield from bold types is larger than that from fine types and the hulling out-turn is also better (*Rep. Marketing Rice*, 1954, 41, 214-22, 82-85; Grist, 79-84).

Depending upon the treatment given to the paddy before hulling, rice can be classified as raw or parboiled. A brief account of the parboiling process has

been given elsewhere. The greater proportion of rice consumed in this country is parboiled, Kerala, West Bengal, Bihar, Orissa and Madras being the States where this is in great vogue. Table 21 gives some important commercial types of rice, classified according to conformation of the grain and treatment given to paddy before conversion, and their main areas of production (*Rice Economy of India, 40 ; Rep. Marketing Rice, 1954, 147*).

Some of the physical characteristics which are definite quality factors and to which a good deal of importance is attached by consumers are: translucence in contrast to chalkiness, colour, polish, fragrance or aroma, age or period of storage after harvest and, lastly, cooking quality. A translucent grain is preferred as such rice does not coagulate on cooking, while chalky rice generally cooks into a glutinous mass. White types are preferred to coloured ones, but in certain areas a yellowish tinge is specially brought about in the rice by prolongation of parboiling and in some other areas a colouring agent is applied to produce grains of a light yellow or red colour, as there is a market for such coloured rice,

though such externally applied colours wash away when the rice is washed in water preliminary to cooking. In this country a high degree of polish is not particularly preferred even when the rice is turned out by power-driven mills. Natural fragrance of rice which persists even after cooking is a much valued factor in some areas where scented rices are grown, such as *Basmati* in Uttar Pradesh, *Mushkan* in Punjab and the less known *Ambemohar* in Madhya Pradesh. The age or the period which has elapsed after rice is harvested is a quality factor of special significance, as most types of rice are not suitable for consumption until they are stored for a few months after harvest (*Rep. Marketing Rice, 1954, 28-32 ; Ghose et al., 311*).

Some of the factors taken into consideration by the trade when buying paddy are: admixtures of different types, proportion of dirt and damaged kernels and the moisture content. In the case of rice, the evaluation is based on such factors as appearance, scent (if it is a scented type), degree of polish, proportion and type of brokens, admixture with other types of rice, damaged and chalky grains, half-hulled

TABLE 21—SOME IMPORTANT COMMERCIAL TYPES OF RICE AND THEIR AREA OF PRODUCTION*

Categories	Trade name	State	1,000 Kernel wt. (in grammes)	Length/Breadth ratio
FINE				
<i>Long fine</i>				
(i) Raw				
	Dehra Dun Basmati**	Uttar Pradesh	14.77	3.60
	Hansraj	do.	14.89	3.33
	Raimunia	do.	12.76	3.26
	Parmal	Punjab	13.05	3.71
(ii) Parboiled				
	Patnai	West Bengal	18.97	3.13
	Kalamkatti	Bihar, West Bengal	15.31	3.62
	Sabaranpur Sela Basmati	Uttar Pradesh	..	3.83
	Raimunia	do.	12.76	3.26
	Kalamdan	Bihar	16.70	3.43
<i>Short fine</i>				
Raw				
	Kamod	Gujarat, Maharashtra	10.99	2.80
	Kolamba	Maharashtra	9.59	2.65
	Jiresal**	do.	10.77	2.40
	Kolipi	do.	10.32	2.66
	Kalikamod**	do.	12.10	2.72
	Chhatri**	Madhya Pradesh	13.95	2.82
	Chinoor**	do.	12.55	2.92
	Banspatri**	do.	8.45	2.19

Contd

TABLE 21—*Contd.*

Categories	Trade name	State	1,000 Kernel wt. (in grammes)	Length/Breadth ratio
MEDIUM	GEB-24 or Kichili samba	Andhra Pradesh, Madras	12.55	2.60
	Krishnakatukalu	Andhra Pradesh	15.00	2.57
	(i) Raw	Begmi	Punjab	18.25
	Sone	do.	11.57	2.76
	Anjana	Uttar Pradesh	14.84	2.65
	Sondhi	do.	13.78	2.04
	Didai	do.	17.13	2.78
	Anji	do.	12.72	2.94
	Rambhog	do.	17.00	2.99
	Luchai	Madhya Pradesh	13.17	2.56
(ii) Parboiled	Budhiabko	do.	14.93	2.67
	Samundarsok	do.	16.12	3.03
	Kersail	Assam	16.18	2.55
	Ambemohar	Mysore	10.14	1.98
	Sattarsal	Gujarat	13.47	2.73
	Akkulu	Andhra Pradesh	15.65	2.48
	Sadaisamba	Madras	11.90	2.28
	Dudhraj	Bihar	17.00	2.50
	Dudhkhanji	do.	11.50	2.78
	Nagra	West Bengal	14.93	2.85
bold or COARSE	Indrasail	do.	15.00	2.46
	Bankutusi	do.	15.88	2.96
	Red Sirumani	Madras	14.06	2.00
	Sirumani	do.	15.16	1.70
	Lati Sali	Assam	15.66	2.41
	Jhona	Punjab	17.23	2.90
	Banki Banshi	Uttar Pradesh	15.20	2.20
	Pahari	do.	15.84	2.35
	Dhani	do.	15.34	1.93
	Gurmatia	Madhya Pradesh	16.41	2.41
(ii) Parboiled	Patni	Maharashtra	16.18	2.22
	Kusumalu	Andhra Pradesh	18.56	2.50
	Konamani	do.	17.80	2.50
	Kodai	Madras	16.53	2.20
	Satraj	Bihar	..	2.45
	Mota Chaudana	do.	16.80	2.41
	Kuruvali	Madras	17.21	2.10

* Rep. Marketing Rice, 1954, 43-55, appx XIV-XXII.

* Scented types.

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kernels and foreign material. There is no precise determination of moisture content before purchasing stocks for storage; moisture content is roughly assessed by crushing the grain between teeth. Quality specifications have been laid down for the evaluation of paddy and rice purchased by Government under the scheme of monopoly purchase and under the scheme of price support. The rice is grouped under several main categories such as fine or coarse, raw or parboiled and milled or hand-pounded and specifications have been laid down in respect of refractions, red grains and moisture content; here again, tolerance limits and rejection limits are specified. The degree of polish has been limited by law to the removal of the bran to the extent of 3–5% [*Rep. Marketing Rice*, 1954, 32; *Rice Economy of India*, 73, 75–77, 83–86; *Manni & Aten, Rice News Teller*, 1958, 6(4), 3].

Agmark—With the ultimate object of bringing about some measure of uniformity in the innumerable and undefined grades or qualities, steps have been taken under the Agricultural Produce (Grading and Marking) Act, 1937, to draw up standard grade specifications based on consumer preference in respect of a number of well-known commercial types belonging to different regions, like *Basmati* and *Hansraj* of Uttar Pradesh, *Molagolukulu*, *Krishnakatukulu* and *Atragadalu* or *Ramasagaralu* of Andhra Pradesh and *Muthusamba*, *Sirumani* and *Kichilisamba* (*GEB-24*) of Madras, and a number of other types totalling about 66 in the various rice producing areas. No specifications have been laid down for paddy (*Rep. Marketing Rice*, 1954, 228–35, 526–33; *Ghose et al.*, 344–48; *Rice Economy of India*, 26–27).

HANDLING AND TRANSPORTATION

Paddy is generally handled in bulk till it reaches the market where it is packed into bags (gunny bags). Rice is generally handled in bags, but hand-pounded rice, which originates in villages, is sometimes handled in bulk like paddy. Standard types of bags are mostly used and fillings of 59–65 kg. are common for paddy, while for rice there is a wide range of fillings from 75–100 kg. or even more.

Rice is moved to the assembling centres in the first instance mostly over road by means of bullock carts, pack animals and head loads and subsequent transportation to distant markets is by motor lorries or over the railways. Movement of rice over internal waterways is also quite common, particularly in West Bengal, Assam, Bihar, Orissa, Andhra Pradesh,

Madras and Kerala. There is also considerable coastal traffic during the fair season (September–May) (*Ghose et al.*, 356–58; *Rep. Marketing Rice*, 1954, 262–84).

Statistics regarding internal trade movement of paddy and rice are limited in scope with regard to the regions covered and mode of transport employed. The statistics cover only 31 trade blocks and movement by rail and rivers only; no account is available of trade by road transport. Table 22 summarizes internal trade in paddy and rice during the period 1961–62 to 1963–64 (*Rice Economy of India*, 91–92).

PRODUCTION AND TRADE

PRODUCTION

Rice is said to be the most extensively cultivated cereal crop in the world, particularly concentrated in Asian countries, which include about 92% of the world rice area. The two most important rice producing countries are China and India which accounted for c. 30 and 28% respectively of the area and 42 and 18% of the production of the world total. In India the rice crop occupies the largest area among all crops. On an average, the area under rice forms 36% of the total area under cereals and 28% of the total area under all food grains including pulses. In respect of production, rice accounts for 48% of the total under cereals and 40% of the total under the food grains (*Rice Economy of India*, 3).

Despite yearly fluctuations, there has been a gradual increase in the area and production of rice in India during the past two decades (Table 7). From about 29.8 million hectares producing about 21.3 million tonnes of rice in 1951–52, the area and production have gone up to nearly 34.2 million hectares, producing c. 34.8 million tonnes of milled rice in 1961–62. This increase in area has taken place in all important States except West Bengal and Bihar. The increase in area is partly due to reclamation of more land and partly due to double cropping in irrigated land, while increase in production has been mainly due to emphasis on seed selection, increased use of fertilizers, adoption of Japanese method of cultivation and better irrigation facilities (*Agric. Situat. India*, 1961–62, 17, 857).

A programme of intensive development of agricultural production in selected districts in seven States has been launched for securing rapid and significant increase in respect of production of rice and other food grains. The programme aims at distribution of improved seeds through seed multiplication farms, distribution of fertilizers and manures, assured irriga-

TABLE 22—INLAND TRADE (RAIL & RIVERBORNE) OF PADDY AND RICE*

(thousand tonnes)

Trade Block	PADDY						RICE					
	1961-62		1962-63		1963-64		1961-62		1962-63		1963-64	
	Exports	Imports	Exports	Imports	Exports	Imports	Exports	Imports	Exports	Imports	Exports	Imports
Andhra Pradesh	113	3	110	(a)	159	(a)	452	30	421	28	613	9
Andhra ports	(a)	(a)	1	(a)	(a)	(a)	42	1	37	1	59	3
Assam	(a)	..	(a)	1	(a)	..	1	9	2	66	(a)	82
Bihar	1	1	2	2	4	1	3	49	2	53	11	42
Delhi	..	..	(a)	..	..	1	5	28	19	10	5	8
Goa	..	..	..	..	(a)	..	..	..	(a)	..	1	13
Gujarat†	..	..	1	1	1	1	..	..	17	131	19	157
Gujarat ports†	..	..	(a)	1	(a)	(a)	..	..	8	51	22	46
Himachal Pradesh	..	..	..	..	..	..	..	4	..	3	..	3
Kerala	3	49	1	49	1	52	8	142	8	136	10	165
Kerala ports	4	1	5	1	6	2	90	517	64	483	31	507
Madhya Pradesh	3	(a)	12	(a)	9	1	454	10	365	7	320	6
Madras	20	128	26	121	25	183	215	50	242	57	280	50
Madras ports	9	18	5	14	5	12	45	54	70	29	44	26
Maharashtra†	3	2	3	1	8	7	106	281	100	143	76	157
Maharashtra ports†	1	2	(a)	15	1	10	94	253	82	192	88	339
Mysore	43	3	34	2	51	2	8	195	3	161	13	122
Mysore ports	..	1	(a)	1	(a)	(a)	9	20	15	34	24	24
Orissa	182	(a)	113	(a)	20	(a)	173	3	200	20	104	13
Pondicherry & Karikal	1	(a)	1	(a)	1	(a)	5	(a)	8	(a)	8	..
Punjab	1	..	7	..	5	..	124	3	117	2	177	1
Rajasthan	(a)	(a)	(a)	(a)	2	1	2	29	2	27	3	21
Tripura	..	..	..	..	..	..	..	(a)	..	8	..	18
Uttar Pradesh	1	1	6	(a)	(a)	(a)	28	67	87	18	78	11
West Bengal	2	130	2	91	1	24	150	147	120	158	82	154
Calcutta port†	2	53	1	33	2	4	105	228	70	241	119	209
TOTAL	391	391	332	332	302	302	2,120	2,120	2,058	2,058	2,188	2,188

* Accounts relating to the Inland (Rail & Riverborne) Trade of India.

† Data for 1961-62 for Gujarat are included in the data for Maharashtra.

(a) Less than 500 tonnes.

tion facilities and adoption of plant protection measures. In addition, steps are being taken to popularize improved cultural practices, including growing of green manures, Japanese method of paddy cultivation, double cropping, eradication of weeds, etc. (Rice Economy of India, 9-15).

IMPORTS

In spite of being the world's second largest producer of rice, India is a net importer, the other

important importing countries being Japan, Malaysia, Indonesia and Ceylon. Though the main factor determining the imports is the excess of over-all demand over domestic supply, the actual quantities imported in post-war years have been greatly influenced by such other factors as availability from abroad, prices prevailing in the exporting countries, commitments under long term agreements, the need to build up buffer stocks, the extent to which the internal demand for rice can be met by supplies of

wheat, which is relatively cheaper in the international markets and is also available on deferred payment or grant basis and, lastly, foreign exchange position. The imports, even though sizeable by themselves, have formed only 1.0–3.7% of the total supplies available within the country. The average annual sea-borne imports of paddy and rice which amounted in undivided India to 143 and 795 thousand tonnes respectively, in the decade ending 1929-30, leapt up to 192 and 1,476 thousand tonnes, respectively, in the succeeding decade, but received a setback with the onset and intensification of World War II and almost ceased from 1942-43 onwards. Along with the sea-borne imports of rice, small quantities amounting to not more than 3.8% of the total imports were received through land routes, mainly from Nepal, Sikkim and Bhutan into the adjoining districts of Uttar Pradesh, Bihar and Bengal. These imports continued over the war years also when, for some years, they formed the whole of the imports of rice. The post-war period from 1947 to 1959 can be broadly divided into three phases in respect of imports of rice

and other cereals. The first phase, which lasted till 1952, was characterized by increasing imports of cereals, though the increase was mainly accounted for by wheat. The average annual imports of all cereals in this period was 3,370 thousand tonnes with rice amounting to about 21% of the total. In the second phase, which lasted till 1955, there was a steep fall in imports of cereals made possible by a sizeable increase in domestic production. The third phase started after 1955 when the domestic demand for cereals began to catch up with production and subsequently exceeded it. Considerable quantities of food grains began to be imported again, the average annual import of all cereals in the period 1955-59 being 3,000 tonnes. The increase in imports was mainly accounted for by wheat, the average annual rice import of 440 thousand tonnes in this period being only 14.5% of total cereals (*Rep. Marketing Rice, 1954-55-65; Rice Economy of India, 52-53*).

Burma has always been India's chief source of rice supplies (Table 23). In the decade preceding World War II, 92% of our imports was received from

TABLE 23—IMPORTS OF RICE (COUNTRY-WISE) AND SHARE OF RICE TO TOTAL CEREALS IMPORTED
(thousand tonnes)

Year	Burma	Thailand	China	U.S.A.	Pakistan	Others	Total rice imported	Total cereals imported	Per cent of rice on total cereals
1948	508 (57.3)	159 (18.0)	..	..	71 (8.1)	146 (16.6)	884	2,888	30.5
1949	379 (48.6)	290 (37.2)	..	..	..	111 (14.2)	780	3,768	20.7
1950	191 (53.3)	113 (31.4)	..	..	..	55 (15.3)	359	2,160	16.6
1951	309 (40.6)	220 (28.8)	67 (8.8)	..	160 (21.1)	5 (0.77)	761	4,804	15.9
1952	382 (52.1)	187 (25.5)	150 (20.5)	..	14 (1.0)	..	733	3,928	18.7
1953	153 (85.7)	2 (1.1)	..	..	23 (13.1)	..	178	2,036	8.7
1954	635 (100.0)	..	..	..	..	..	635	844	75.3
1955	269 (100.0)	..	..	..	..	..	269	711	37.9
1956	279 (84.3)	..	47 (14.1)	..	5 (1.5)	..	331	1,444	22.9
1957	484 (64.7)	33 (4.5)	14 (1.9)	197 (26.4)	12 (1.6)	7 ^a (1.0)	747	3,648	20.5
1958	390 (98.2)	..	..	..	..	7 ^a (1.8)	397	3,226	12.3
1959	295 (100.0)	..	..	..	..	..	295	3,870	7.6
1960-61	215 (54.1)	..	..	83 (20.8)	..	100 ^b (25.1)	398	3,898	10.2
1961-62	186 (58.5)	..	..	105 (33.0)	..	27 ^c (8.5)	318	2,525	12.6
1962-63	139 (31.8)	..	..	298 (68.2)	..	..	437	3,005	14.5
1963-64	151 (34.0)	10 (2.2)	..	276 (62.2)	..	7 ^a (1.6)	444	3,416	13.0

^a Source of import, S. Vietnam. ^b Source of import, United Arab Republic. ^c Malaya supplied 9,600 and United Arab Republic 6,800 tonnes.

Figures in brackets indicate percentage of rice imports from each country to total rice imports.

Burma and the rest from Indo-China and Thailand. In post-war years also Burma has been the chief supplier. During the period 1948-52, about half of India's total rice imports came from Burma, though Burmese rice production had not by then fully recovered and a substantial part came from Thailand. Substantial quantities were also imported from Pakistan and China in some years of the post-war period till 1956. From then onwards, U.S.A. has been contributing an increasing share to our rice imports and has even replaced Burma as the principal supplier in the years 1962-64. The United Arab Republic has also supplied significant quantities in some years (*Rep. Marketing Rice*, 1954, 57; *Rice Economy of India*, 54-55).

To control supplies from internal as well as external sources, the Government took over in 1943 the monopoly of purchase of rice and other food grains and prohibited import on private account. Government entered also into agreements and contracts with exporting countries from time to time for the import of specified quantities of the commodity. Two types of agreements have been made, the medium term import agreement, serving to ensure a market for the exporting countries and continued supplies to India and the other, import under special arrangements (e.g. U.S. Public Law 480), helping the exporting countries in the disposal of their produce at reasonable terms and also enabling India to obtain her essential rice imports, without aggravating her balance of payments position (*Rice Economy of India*, 56).

A major part of the imported rice is directed to Calcutta, and to Kerala ports for supply to West Bengal and Kerala respectively, the two States which are highly deficit. Bombay port also accounts for a sizeable part in some years.

EXPORTS

Prior to World War II undivided India used to export some quantities of rice amounting on an average to about 238 thousand tonnes (1935-36 to 1939-40) and the exports continued up to 1942-43 when they were banned in view of the serious domestic shortage of food grains. Ceylon was the chief importer, while South Africa, Mauritius and the Persian Gulf countries took smaller quantities. The ban on exports was lifted in July 1954 following a substantial increase in internal production, but was reimposed again early in 1956. A quantity of about 152 thousand tonnes was exported during this period, the chief importing countries being Mauritius and

Saudi Arabia, followed by Ceylon, Malaya and other countries (*Rep. Marketing Rice*, 1954, 66-73; *Rice Economy of India*, 57, 162, Table 3.2).

Some quantity of bran is also exported, mainly to U.K. The total quantity exported annually during the past three years (1961-63), ranged from 36 to 42 thousand tonnes, valued at 59-72 lakhs rupees.

CONSUMPTION

Rice forms about one-half of the total amount of cereals consumed in the country, while wheat makes up about one-sixth and millets make up the remaining one-third (Table 24). The pattern of consumption in different parts of the country is naturally set by the pattern of production which in turn is controlled by climate and soil. In the eastern States, where both climate and soil are suitable for rice growing, the consumption habits of the people have developed around rice, while in the southern and central States where rainfall or irrigation facilities are not always adequate for rice, and millets can easily be grown in the drier areas, the consumption pattern is based partly on rice and partly on millets. In the northern and north western areas both climate and distribution of rainfall favour in general the cultivation of wheat rather than rice, so that wheat predominates in regard to production and consumption. The predominantly rice consuming areas in the country are Assam, Manipur, Tripura, southern Bihar, West Bengal, Orissa, eastern parts of Maharashtra, southern Mysore, coastal areas of Maharashtra and Mysore, Madras, Kerala, hilly districts of Uttar Pradesh and Punjab, Himachal Pradesh and Jammu & Kashmir. The per capita consumption of rice is highest in Assam and lowest in the Punjab. With increasing production of rice the quantity of rice available for consumption has gradually risen from 23 million tonnes in 1950 to about 32 million tonnes in 1962. This increased consumption is attributed to the fairly rapid rate of urbanization and increasing demand for rice and wheat in preference to millets (*Rice Economy of India*, 43-51).

PRICES

A comparison of the rice prices ruling in the different parts of the world is made rather complex by the artificial conditions imposed in several countries on the free movement of trade, through tariff walls, quotas, exchange and currency regulations and barter agreements. International trade in rice during and since World War II has been regulated

TABLE 24—NET AVAILABILITY OF RICE FOR CONSUMPTION IN INDIA*
(million tonnes)

Year	Production		Net production† available for consumption		Net imports		Net availability‡ for consumption	
	Cereals	Rice	Cereals	Rice	Cereals	Rice	Cereals	Rice
1950	49.17	24.13	43.03	22.51	2.15	0.35	46.04	23.24
1951	44.47	21.20	38.90	19.78	4.80	0.76	43.17	20.47
1952	45.03	21.74	39.39	20.29	3.92	0.73	42.70	20.81
1953	50.34	23.36	44.01	21.79	2.03	0.18	46.53	22.09
1954	59.29	28.61	51.88	28.66	0.83	0.62	52.51	26.28
1955	57.32	26.50	50.15	23.82	0.60	0.16	51.49	24.85
1956	55.85	27.56	48.87	25.71	1.40	0.28	50.91	26.53
1957	58.34	29.05	51.03	27.10	3.65	0.75	53.80	27.31
1958	53.88	25.29	47.15	23.70	3.22	0.39	50.64	23.99
1959	63.67	30.86	55.71	28.79	3.87	0.29	59.08	28.70
1960**	64.20	31.46	56.18	29.07	3.90	0.40	59.91	29.41
1961**	68.32	34.20	59.78	31.60	2.53	0.32	63.44	32.10
1962**	69.40	34.80	59.64	31.56	3.00	0.44	63.64	32.25

* Rice Economy of India, 45. ** Provisional. † Net production represents production minus quantities accounted for seed, feed and wastage.

‡ Net availability for consumption represents net production plus net imports plus/minus changes in Government stocks.

by special measures of control and allocation on both national and international levels. Domestic prices in certain Asian countries like Burma are divorced from export prices as a result of Government control of the trade in rice. In India, the internal rice prices have been under Government control while the import prices are subject to negotiations with the exporting countries (Ghose *et al.*, 317-18; *Rep. Marketing Rice*, 1954, 97, 100).

An analysis of the trend of prices of rice within the country is also much complicated because of several factors such as the existence of an extraordinarily large number of commercial types of rice, the preferences of consumers which are of a complex nature and also because the demand for any type of rice is rather of a localized nature. Fine types are dearer than medium types which in turn are dearer than the bold ones. Parboiled rices are in general cheaper than the corresponding raw rices, as the parboiling treatment reduces breakage in husking and gives a higher out-turn of whole grain. Hand-pounded rices are usually dearer than machine milled rices because of the higher cost of manual labour in hand-pounding. The prices of rice and paddy are also subject to

seasonal fluctuations, the prices falling during the harvest months. In general, cheap types show a greater variation than the dearer types. Age of storage of rice has also its influence and rice stored for sometime or produced from stored paddy generally sells dearer than the newly harvested produce. In addition to the above there is the variation in price due to quality or grade also (*Rep. Marketing Rice*, 1954, 95-96, 101-28, 459; Ghose *et al.*, 319-22).

The price relationship between paddy and rice depends upon many factors, the most important of which is the out-turn of rice from paddy. For all practical purposes three units of paddy are reckoned to yield on an average two units of rice, so that the price of any particular type of paddy should theoretically be in the neighbourhood of 66-67% of the value of the corresponding rice. But this is often far from the case, as the out-turn of rice from paddy differs from one type to another and besides there are other factors which influence the price relationship between paddy and rice, such as the method adopted to convert the paddy to rice and the proportion of broken grains and fragments allowed to

remain in the rice. The prices may also fluctuate independently on account of the many quality factors and market conditions. In some areas like Madras and West Bengal, the relation between paddy and rice prices does not vary greatly, while in the case of the fine rices of northern India which are more susceptible to breakage and often involve a good deal of dressing and sifting the proportion borne by the price of paddy to that of rice may be anywhere between the extreme limits of 35 and 75% (Ghose *et al.*, 322-23; *Rep. Marketing Rice*, 1954, 128-32).

As is the case with all other agricultural produce, the prices of rice and paddy are subjected to well defined seasonal fluctuations tending to fall during the harvest and post harvest months from November to February or March. The exact extent of fluctuations naturally varies from market to market and from one type of rice to another and depends also on various factors such as the nature of the crop, prospects of the new crop and the prices of other competitive crops. The extent of variation is more with regard to paddy chiefly because the primary seller in this case is the cultivator who has no means of regulating supplies to the demand, whereas the primary seller of rice is either a merchant or miller who can adjust supplies to the demand (*Rep. Marketing Rice*, 1954, 101; *Rice Economy of India*, 67-70).

There has been much greater stability in rice prices during 1950-60 as compared to the period 1940-50. The increase in population at a rapid rate, increasing urbanization and consequent urban habits of diet, rise in real incomes consequent on progressive industrialization and inflationary pressures created a strong demand on the rice market during 1950-60. This has been met by a substantial increase in production during this period resulting in a reasonable degree of stability in rice prices, taking into consideration the period as a whole.

The Government has taken recourse to several measures in this period to keep prices down, such as increasing the imports of rice, re-imposition of embargo on export of food grains, restrictions on bank credits against stocks of food grains, fixation of maximum controlled prices, procurement of stocks of rice at controlled rates from surplus areas, licensing of food grain dealers and millers and the prohibition of forward trading in food grains. Another important measure undertaken to control rice prices has been the formation of several rice zones in the country with a view to avoid crop movement of the commodity, reduce speculative activity and promote

regional self-sufficiency. To begin with, the Southern Rice Zone consisting of Andhra Pradesh, Madras, Mysore and Kerala was formed in 1957 and this was followed later by the Northern Zone comprising Punjab, Delhi and Himachal Pradesh, the Eastern Zone comprising Orissa and West Bengal and recently the Western Zone comprising Madhya Pradesh, Maharashtra and Gujarat. The Government also decided early in 1960 to build up through imports a reserve stock of one million tonnes of rice along with four million tonnes of wheat to serve as a deterrent to speculative forces and help in preventing wide fluctuation in prices and to meet any food shortage due to fluctuations in production (*Rice Economy of India*, 59-67).

Osage Orange — see Maclura

OSBECKIA Linn. (*Melastomataceae*)

A genus of herbs, subshrubs or shrubs distributed in the tropical parts of the eastern hemisphere. More than thirty species occur in India.

O. crinita Benth.

D.E.P., V, 654; Fl. Br. Ind., II, 517.

NEPAL—*Tsulesi*; BHUTAN—*Hlandi samba*; LEPCHA—Number; KHASI—*Ja-lang-kthem*, *dieng-soh-kthem*; LUSHAI—*Builukham*.

A small shrub, 1.2-2.4 m. high, found in the Himalayas from Simla to Bhutan, Chota Nagpur, northern Bengal and Khasi, Aka and Lushai hills at altitudes of 900-2,550 m. Leaves lanceolate to oblong-lanceolate, bristly on both surfaces; flowers purple or pure white, in terminal clusters; capsules ovoid, suddenly narrowed to a neck; seeds numerous, minute.

The wood of the plant is light brown, moderately hard. A decoction of root is given in China as a stomachic for promoting appetite and that of the dried leaves for toothache in Tongking (Cheo, *Bot. Bull. Acad. sinica*, 1947, 1, 305; Kirt. & Basu, II, 1070).

O. chinensis Linn. (MUNDARI—*Gara jojo ara*; LUSHAI—*Builukham*) is a slender undershrub, 60 cm. high, with linear-lanceolate or oblong leaves and mauve or purple flowers found in the Himalayas from Garhwal to Bhutan, Bihar, North Bengal, and Khasi, Aka and Lushai hills and in N. Circars. The plant is used by the Mundas for diarrhoea and for wounds of the cattle. The roots of the plant are chewed and the saliva is swallowed for coughing (Bressers, 63; Fox, *Philipp. J. Sci.*, 1952, 81, 323).

OSBECKIA

O. cupularis D. Don ex Wight & Arn. (MAL.—*Cherkualathi*) is a small, herbaceous perennial, 20–50 cm. high, with elliptic-oblong leaves and white flowers tinged with pink found growing in the western ghats in Mysore, Kerala, Nilgiri and Palni hills at altitudes of 900–2,100 m. The whole plant is pounded and applied to swellings (Rama Rao, 174).

O. nepalensis Hook. (ASSAM—*Baga phatkala*) is a small shrub, 1.5 m. high, with lanceolate leaves and white or mauve flowers found in the sub-tropical Himalayas from Nepal eastwards, and in North Bihar, North Bengal, Assam, Khasi and Naga hills up to an altitude of 1,700 m. In Lakhimpur, the flowers of the plant are pounded and applied to sores in mouth (Kirt. & Basu, II, 1070).

OSMANTHUS Lour. (Oleaceae)

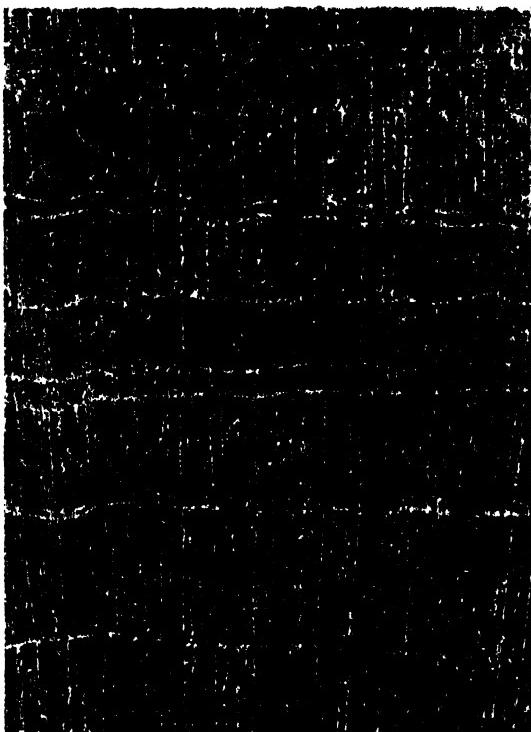
A genus of shrubs or trees distributed from South and East Asia to Pacific Islands and North America. Two species are found in India.

O. fragrans Lour.

D.E.P., V, 654; Fl. Br. Ind., III, 605.



FIG. 71—OSMANTHUS FRAGRANS—FLOWERING BRANCH



F.R.I., Dehra Dun. Photo: S. S. Ghosh

FIG. 72—OSMANTHUS FRAGRANS—TRANSVERSE SECTION OF WOOD (x10)

U.P. HILLS Silang; N. BENGAL & LEPCHA—Tungrung.

An evergreen shrub or a small to medium-sized tree found in the Himalayas from Yumuna eastwards at altitudes of 1,600–2,900 m. and in the hills of Assam. Bark dark brown or blackish; leaves oblong or lanceolate, dark green, coriaceous; flowers in dense fascicles, white or yellowish, 5–6 mm. in diam., very fragrant; drupes ovoid, dark purple.

O. fragrans is extensively cultivated for its flowers, which have a sweet smell resembling jasmine. It prefers partial shade and is easily propagated by cuttings or gootees. The flowers are used in China for flavouring tea and medical preparations; mixed with sesamum oil, they serve also as a cosmetic. They also find use as a flavouring for confectionery and bakery products; for this purpose the flowers are preserved in alum solution and washed in running water before use. In Kumaun, the flowers are used to protect clothes from insects. Fruits are reported to be edible (Bor & Raizada, 226; Roi, 259; Poucher, I, 309; Willis, 475).

The flowers (of *O. fragrans* var. *aurantiacus*

Makino from Japan) on extraction with petroleum ether and subsequent treatment with alcohol yield 0.16% of a fragrant oil with the following constants: d_{20}^{20} , 0.9037; n_{D}^{20} , 1.4946; $[\alpha]_D^{12.5}$, +9.14°. An odorous component osmanc (1, 2-dimethyl-3-isopropyl cyclopentane), β -[4-oxyphenyl]-ethyl alcohol, and acetic, succinic, stearic and palmitic acids have been identified in the oil. The flowers contain also oleanolic acid, ursolic acid, β -sitosterol, glycosides, and a wax (0.04%) composed mainly of triacontane. The leaves are reported to contain a phillyrin-like glycoside (Gildemeister & Hoffmann, VI, 557; *Chem. Abstr.*, 1955, 49, 16358; 1957, 51, 15069; 1958, 52, 10506, 18682; Wehmer, II, 953).

The wood of *O. fragrans* is white to light yellow or brown in colour, fine-textured, hard and heavy (wt., c. 801 kg./cu.m.); it produces an attractive figure in the longitudinal plane. It is suitable for tool handles, toys, combs and turnery work [Chowdhury & Ghosh, *Indian For. Rec.*, N.S., *Util.*, 1947, 4(3), 16].

O. suavis King (NEPAL—*Silingi*; BHUTAN—*Chashing*) is a small tree found in eastern Himalayas at altitudes of 2,700–3,000 m. and in Aka hills in Assam. The wood resembles that of *O. fragrans* and is white, close-grained, hard and heavy (wt., 849 kg./cu.m.). It seasons well and presents a mottled appearance in vertical section (Gamble, 472).

OSMORHIZA Rafin. (*Umbelliferae*)

A small genus of perennial herbs distributed in Asia and America. One species occurs in India.

O. aristata (Thunb.) Makino & Yabe var. *laxa* (Royle) Constance & Shan syn. *O. claytoni* C. B. Clarke (in part); *O. laxa* Royle

Fl. Br. Ind., II, 690; Hiroe, 30.

An erect perennial herb, 60–150 cm. high, found in the Himalayas from Kashmir to Nepal at altitudes of 1,500–2,400 m. Leaves biennial: leaflets coarsely toothed or sometimes sparsely lobed; flowers white, in umbels; fruits nearly cylindric, covered with minute, scattered bristles.

No information is available regarding the economic uses of the Indian plant. The Indian plant does not have tuberous roots. In America, the roots of two allied species, *O. claytoni* and *O. longistylis* DC., are considered aromatic and used for flavouring. They are said to possess also expectorant, demulcent, carminative and stomachic properties [Krishna & Badhwar, *J. sci. industr. Res.*, 1953, 12(2), suppl., 282; Khan, *Pakist. J. For.*, 1958, 8, 365; Hocking, 158; Jacobs & Burlage, 216].

OSMUNDA Linn. (*Osmundaceae*)

Beddome, *Indian Ferns*, 447; Blatter & d'Almeida, 192.

A genus of ferns distributed in the temperate and warm temperate parts of the world. Two species occur wild in India and some exotics have been introduced into gardens.

Osmunda spp. have either upright or creeping, bifurcating stems, invested with persistent remains of old leaf bases. They are grown for their ornamental crowns of fronds. In some species, such as *O. claytoniana* Linn., the fronds are dimorphic, while in others like *O. regalis* Linn. both the fertile and sterile pinnae may be found in the same frond (Smith, 1949, II, 287; Copeland, 21).

O. regalis Linn. (ROYAL FERN) is found in the moist parts of the Himalayas, Khasi hills and the western ghats at altitudes of 1,500–3,000 m. The roots are mucilaginous, tonic, stimulant and styptic. An aque-

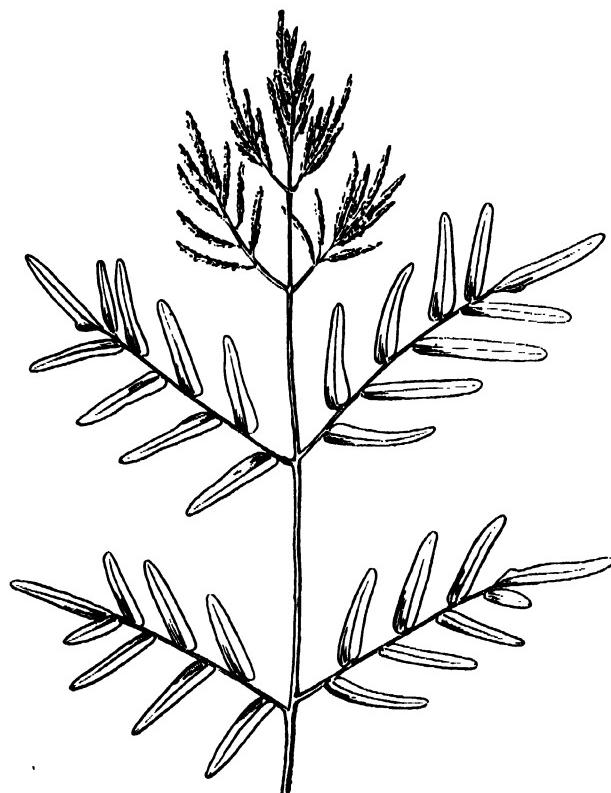


FIG. 73—OSMUNDA REGALIS STERILE AND FERTILE PINNAE

OSMUNDA

ous extract of the fern is administered for intestinal grippe and used externally in rheumatism. It is said to have antibacterial action. The fern is also prescribed in dysentery, rickets and muscular debility; tender sprigs are used in balms and healing plasters. The fronds enter into the preparation of diuretic drinks, used in body swellings (Jacobs & Burlage, 158; Kirt. & Basu, IV, 2750; Puri & Arora, Indian For., 1961, 87, 182; Caius, J. Bombay nat. Hist. Soc., 1935-36, 38, 359; Crevost & Petelot, Bull. econ. Indoch., 1935, 38, 133).

Powdered rhizomes yield 1.14% of ether extractives containing saccharose, and some glucose and fructose (Chopra, 1958, 650).

The rhizomes and stipe bases of *O. claytoniana* found in the Himalayas and Khasi hills at altitudes of 1,500-3,500 m. are employed as an adulterant and substitute of *Filix-mas* (Youngken, 105; U.S.D., 1955, 122).

The roots of *O. claytoniana* are used in America and Europe in the preparation of a rooting medium (Osmandine) for growing epiphytic orchids (Bailey, 1947, II, 2414).

OSTODES Blume (*Euphorbiaceae*)

D.E.P., V, 654; Fl. Br. Ind., V, 400.

A genus of trees or shrubs distributed in Indo-Malaysian region. Three species are found in India.

O. paniculata Blume (NEPAL—*Bepari*; LEPCHA—*Palok-kung*; ASSAM—*Dieng-ja-tung, tasichange*) is a handsome evergreen tree, up to 18 m. in height, with a bole, c. 9 m. in length and 2.4 m. in girth, having greyish bark, ovate or cordate leaves and panicles of rosy-white flowers; it is found in eastern Himalayas and hills of Assam up to an altitude of 1,800 m. It yields a gum useful for sizing paper. The wood (wt., c. 417 kg./cu.m.) is white and soft and is used for planking in Burma. The tree provides a poor quality fodder (Rodger, 64; Laurie, Indian For. Leafl., No. 82, 1945, 15).

OSYRIS Linn. (*Santalaceae*)

A genus of shrubs or trees distributed in Africa and from S. Europe to South-East Asia. One species occurs in India.

O. wightiana Wall. ex Wight syn. *O. arborea* Wall.

D.E.P., V, 655; Fl. Br. Ind., V, 231.

MAR.—*Popli, total*; KAN.—*Kuriganda, baingani*.

N. W. HIMALAYAS, GARIHWAL, & KUMAUN—*Dalmia, dalmia*; NEPAL—*Jhuri, num nugi*.

An evergreen shrub or a small tree, partially parasitic on other plants, found in the sub-Himalayan tracts and outer Himalayas from Kangra eastwards, up to an altitude of 2,100 m., and in Assam, central India and hills of S. India above 600 m. Leaves elliptic-lanceolate or obovate; flowers minute, yellowish green, polygamous; drupe sub-globose, yellow or red.

An infusion of the leaves has powerful emetic properties but in earlier years they have been used as a substitute for tea in Kumaun. Their first infusion in hot water is reddish and nauseating and is discarded; the second, which is used, is yellowish green. The leaves contain 20% tannin and are considered worthy of investigation as a substitute for sumach (*Cotinus coggyria*). The leaves are subject to the attacks of *Meliola osyridicola* Hansf. and *Sphaceloma osyridis* Thirumalachar (Hooper, Agric. Ledger, No. 1, 1902, 50; Thirumalachar, Trans. Brit. mycol. Soc., 1947, 31, 1).

The wood is light to dark red, close-grained, smooth, hard and heavy (wt., 865-993 kg./cu.m.). It is used for making walking sticks. The heartwood is faintly fragrant and is reported to be used for adulterating sandalwood (Talbot, II, 427; Gamble, 588; Thirumalachar, loc. cit.).

Otaheite Apple—see *Spondias*

OTTELIA Pers. (*Hydrocharitaceae*)

A genus of submerged or partially floating freshwater herbs distributed almost exclusively in the paleotropics and Brazil. Two species occur in India.

O. alismoides Pers.

Fl. Br. Ind., V, 662; Fl. Malesiana, Ser. I, 5(4), 398. Fig. 10 & 11.

BENG.—*Parmikalla*; TEL.—*Nir-veneki*; KAN.—*Kottigenasuballi, hasuru neeru patre*.

MUNDARI—*Lundi ara*.

A succulent flaccid aquatic herb found throughout India in tanks, ditches, sluggish streams and flooded rice fields. Leaves variable in shape: submerged leaves narrow or oblong, tapering to the base, floating leaves oblong or orbicular, cordate or rounded at the base; flower white, in a tubular spathe; fruit oblong, crowned by persistent perianth; seeds numerous, oblong, with a pulpy testa.

The leaves and petioles possess an excellent flavour, and are used as vegetables. The fruit is eaten by children. When grown in aquaria the plant serves as food for the fish *Etroplus* sp. The plant is said to



FIG. 74—OTTEIA ALISMOIDES

possess rubefacient properties. In Philippines, the leaves are used in topicals to cure haemorrhoids ; they are also applied as poultices on arms and legs in fever (Brown, 1941, I, 88 ; Burkill, II, 1614 ; Gopinath, *J. Bombay nat. Hist. Soc.*, 1942-43, 43, 664 ; Quisumbing, 83).

Otters — see **Weasels**

OUGEINIA Benth. (*Leguminosae* : *Papilionaceae*)

A monotypic genus, comprising a valuable timber tree, native of India.

O. oojeinensis (Roxb.) Hochr. syn. O. dalbergioides Benth. SANDAN

D.E.P., V, 657 ; Fl. Br. Ind., II, 160.

HINDI.—*Sandan*, *panjan*, *tinsa*, *panan* ; BENG.—*Tinis* ; MAR.—*Tiwas*, *kalaphulas* ; GUJ.—*Tanach* ; TEL.—*Tella motuku* ; TAM.—*Narivengai* ; KAN.—*Kuri-mutal*, *kari-honne* ; MAL.—*Malavenna* ; ORIYA.—*Bandhona*, *banjan*.

NEPAL & LEPCHA.—*Sandan pipli* ; BIHAR & ORISSA.—*Ruta*, *pandan*, *tinsa* ; MADHYA PRADESH.—*Tinas*, *tinsa*, *sar*.

TRADE.—*Sandan*.

A small to medium-sized deciduous tree, about 12 m. in height and 1.35 m. in girth, with fairly straight to crooked trunk found in the outer Himalayas and sub-Himalayan tracts from Jammu to Bhutan up to an altitude of 1,500 m. and extending through the whole of northern and central India into the greater part of Deccan Peninsula. Bark grey or brown, deeply cracked ; leaves pinnately trifoliate : leaflets coriaceous ; flowers in short fascicled racemes, white or pink, somewhat fragrant : pods flat, light brown, 2-5 seeded. The tree looks pretty in flower and is sometimes planted in gardens.

Sandan is common, sometimes almost gregarious, in mixed deciduous forests. It is common also in sal forests ; at higher elevations in the Himalayas, it is associated with *Pinus roxburghii* Sarg. It grows on a wide variety of soils and thrives even on poor ground, where, however, it does not attain large dimensions. It is a characteristic species of landslips, banks and sides of rivers and exposed situations : on alluvial loam it attains a comparatively large size. In favour-



F.R.I., Dehra Dun

FIG. 75—OUGEINIA OOJEINENSIS



FIG. 76—*OUGEINIA OOJEINENSIS*—FLOWERING AND FRUITING BRANCHES

able localities, particularly in central India and western parts of Deccan Peninsula, the tree attains a height of over 18 m. with a fairly straight bole c. 7 m. in length and 2 m. in girth; in the Dang forests in Gujarat a height of 30 m. has been recorded (Troup, I, 253; Santapau, *J. Gujarat Res. Soc.*, 1954, 16, 285).

The tree produces suckers in great abundance, which arise from long and spreading roots on or near the surface of the ground; on this account it is useful for clothing unstable steep banks and hill sides. It coppices well. Natural reproduction by seeds takes place early in the monsoon and is generally abundant on bare loose ground, landslips, along roadsides and on cultivated fields. Artificial reproduction may be done by root cuttings. Shoot cuttings give indifferent results, while entire planting has not proved successful. Reproduction by seeds is best obtained by line sowings accompanied with regular weeding; 450 g. of pods are required for 90 m. of line. Direct sowing is preferable to transplanting nursery raised seedlings

(Troup, I, 254–56; Kadambi & Dabral, *Indian For.*, 1955, 81, 129; Purkayastha & Krishnaswami, *ibid.*, 1958, 84, 137).

The tree requires a certain amount of shade in early stages, but once established, full overhead light is necessary for development. Although tender to drought and frost when young, it is afterwards hardy. It is subjected to browsing by cattle and deer and also suffers considerably from fire (Troup, I, 254).

Sandan is susceptible to heart rot [*Fomes caryophylli* (Racib.) Bres.]. The timber is attacked by buff brown pocket rot [*Polystictus nilgheriensis* Mont.] and white spongy rot [*Asterostromella rhodospora* Wakef.=*Vararia rhodospora* (Wakef.) G.H. Cunn. and *Trametes lactinea* Berk.]. The tree is susceptible to a number of defoliators and borers; the latter also attack dead wood (*Indian J. agric. Sci.*, 1950, 20, 107; Kadambi & Dabral, *Indian For.*, 1954, 80, 653; Information from F.R.I., Dehra Dun).

Sandan yields a valuable timber. Sapwood is grey, narrow; heartwood light golden brown when freshly exposed, ageing to reddish brown, with darker streaks, somewhat lustrous, narrowly interlocked-grained, coarse-textured, elastic, tough, strong, very hard and heavy (sp. gr., c. 0.84; av. wt., 865 kg./cu. m.). The wood air seasons slowly without much degrade. Green conversion accompanied by boxing of unsound hearts and stacking under cover in a well ventilated place gives good results. Seasoning in the log or in rough squares is also satisfactory; removal of bark is recommended to prevent insect attack. The wood can also be kiln-seasoned without any difficulty, but requires slow and careful drying; 2.5 cm. thick planks take 16–20 days to season (Pearson & Brown, I, 353; Liimaye, *Indian For. Rec.*, N.S., *Timb. Mech.*, 1954, 1, 56; Trotter, 1944, 145; Rehman, *Indian For.*, 1953, 79, 369).

The wood is durable and is far less liable to termite attack than many other Indian timbers. Graveyard tests indicate a natural durability of 10–15 years.

The timber is difficult to saw and work; it planes and turns well, but is hard on the cutters. By careful handling, it can be finished to a smooth, fine surface which takes a lasting polish. The data for the comparative suitability of sandan timber, expressed as percentages of the same properties of teak, are: weight, 120; strength as a beam, 80; stiffness as a beam, 75; suitability as a post, 80; shock-resisting ability, 120; retention of shape, 60; shear, 140; and



F.R.I., Dehra Dun. Photo : S. S. Ghosh

FIG. 77—*OUGEINIA OOJEINENSIS*—TRANSVERSE SECTION OF WOOD ($\times 10$)

hardness, 145 (Purushotham *et al.*, *Indian For.*, 1953, 79, 49; Pearson & Brown, I, 355–56; Limaye, loc. cit., Sheet No. 15).

The wood is used in cart and carriage building, especially for shafts, axles and hubs; it is used for agricultural implements, sugarcane crushers, tool handles, bed legs, tent poles and pegs, oars and other articles where strength and toughness are necessary. It is used also in construction work, chiefly for posts, rafters, beams, struts, and door and window frames and for some of these purposes is recommended as a substitute for teak and sal. Though a little heavy for furniture and cabinet work, it is used for these purposes and selected stock is quite ornamental. Sandan wood is suitable for textile mill shuttles, spindles, bobbins and picker arms, disc dowels and cooperage (Pearson & Brown, I, 356; Trotter, 1944, 227; Krishnamurti Naidu, 92; Limaye, loc. cit.; *J. Timb. Dryers' & Pres. Ass. India*, 1956, 2(1), 23; Masani, *Indian For.*, 1955, 81, 774).

Sandan is a useful lac host. Experimental trials have shown that it yields good *Baisakhi* crops;

it gives more broodlac for the following *Katki* crop than either *palas* (*Butea monosperma*) or *ber* (*Ziziphus mauritiana* Lam.); it can be alternated with the latter hosts to maintain the vigour of the brood (Purkayastha & Krishnaswami, loc. cit.).

The tree is lopped for fodder. It yields a bast fibre useful for cordage. The bark is used as a febrifuge and also as fish poison; it contains 7% tannins. A kino-like exudation from the incised bark is used in diarrhoea and dysentery. The heartwood contains a dimethoxy isoflavone, homoferreririn ($C_{17}H_{16}O_6$, m.p. 168–9°) and an isoflavanone, ougenin (5,2,4-trihydroxy-7-methoxy-6-methyl isoflavanone, $C_{17}H_{16}O_6$, m.p. 238–40°) [Laurie, *Indian For. Leaflet*, No. 82, 1945, 3; Krishnamurti Naidu, 123; Kirt. & Basu, I, 756; Edwards *et al.*, *Indian For. Rec., N.S., Chem. & Minor For. Prod.*, 1952, 1(2), 153; Balakrishna *et al.*, *J. sci. industr. Res.*, 1961, 20B, 134].

Ounce — see Leopards

OURATEA Aubl. (*Ochnaceae*)

A genus of trees or shrubs distributed in the tropics. Two species are found in India.

O. serrata (Gaertn.) Robson syn. *O. zeylanica* (Lam.) Alston; *O. angustifolia* (Vahl) Baill.; *Gomphia angustifolia* Vahl

D.E.P., III, 533; Fl. Br. Ind., I, 525; Kirt. & Basu, Pl. 208.

MAR.—*Valermani*; TAM.—*Ramanchi, anaivilavu*; KAN.—*Addane, kempokallu*; MAL.—*Chavakampu, aneperala*.

A small tree, c. 9 m. in height, found in the evergreen forests from S. Konkan to Tirunelveli up to an altitude of 900 m. Leaves oblong-lanceolate; flowers in dense panicles, yellow; drupes small, ovoid or reniform.

Wood is reddish brown, even-grained and hard; it is durable, resistant to termite attack and can be easily sawn. It is used in house construction for posts, rafters and wall boards. The root and leaves are bitter and are used in decoction as tonic and stomachic (Gamble, 137; Lewis, 86; Kirt. & Basu, I, 516; Nadkarni, I, 586).

O. hookerii Burkhill syn. *Gomphia hookerii* Planch. is a small tree found in the Andaman Islands. It yields a pinkish, hard and fine-grained wood, reported to be used in house building. In Malaya, the leaves are chewed as a masticatory (Parkinson, 114; Burkhill, II, 1615).

OXALIS

Ouvarovite — see Garnet

OXALIS Linn. (*Oxalidaceae*)

A large genus of annual or perennial herbs, rarely subshrubby distributed mostly in South Africa, including Malagasy (Madagascar), and tropical and sub-tropical America; a few species occur in temperate regions, while one or two species are widely distributed over the tropics. One species is indigenous to India, while several exotic species have established themselves so thoroughly that they are now found growing wild.

Some species of *Oxalis* are grown for ornament, in window-gardens and conservatory, and in hanging baskets; they are also grown in borders and rockeries. A few are grown for their edible bulbous roots; several species are common weeds. They are propagated by bulbs or division of the roots and by seeds (Bailey & Bailey, 524-25; Bailey, 1949, 600; Gopala-swamiengar, 497).

O. acetosella Linn. COMMON WOOD-SORREL

D.E.P., V, 658; Fl. Br. Ind., I, 436; Calder, Rec. bot. Surv. India, 1919, 6(8), 326, 340, Pl. 1.

KUMAUN—*Amrul, chalmori*.

A small delicate, stemless perennial herb, 5-15 cm. high, with a long or short horizontally creeping, reddish knotty scaly rhizome found in temperate Himalayas from Kashmir to Sikkim at altitudes of 2,400-3,600 m. Leaves radical, trifoliolate with elongated petiole: leaflets broadly obovate; flowers solitary, white or pale-rose, veined with purple, yellowish at base, on elongated slender peduncles; fruit a capsule, 8 mm. long, egg-shaped with 2-3 seeds in each cell.

The leaves of the plant possess a refreshing sub-acid flavour, and are used as a substitute of sorrel (*Rumex acetosa* Linn.); they are used in salad and in parts of Europe as a spring vegetable. The leaves contain large amount of potassium oxalate (0.86% in leaf juice). They are rich in vitamin C (183 mg./100 g.). The milk of cows feeding on *O. acetosella* yields butter with difficulty when churned (Edlin, 51; Uphof, 260; Medsger, 165; Wehmer, I, 591; Hocking, 158; Chem. Abstr., 1947, 41, 5584; Singh & Kohli, Indian vet. J., 1956, 32, 278).

The plant possesses refrigerant, diuretic and anti-scorbutic properties. It is used in liver and digestive disorders, febrile diseases, urinary affections, catarrh, gonorrhoea and haemorrhage; it is used also to remove cancerous growths from the lips. In England,

an antiputrescent gargle is concocted against quinsy with the leaves and petals of the plant. The plant is used in homeopathic medicine. It is poisonous when taken in large doses (Kirt. & Basu, I, 439; Wren, 327; Hoppe, 628; Jacobs & Burlage, 158).

O. corniculata Linn. INDIAN SORREL

D.E.P., V, 658; Fl. Br. Ind., I, 436; Calder, Rec. bot. Surv. India, 1919, 6(8), 331, 340.

HINDI & BENG.—*Amrul sak, chuka tripati*; MAR.—*Ambuti, anjati, bhinsarpatti*; TEL.—*Pulichinta*; TAM.—*Puliyarai*; KAN.—*Hulichikkai, pullam purachi, uppinasoppu*; MAL.—*Puliyarel*.

PUNJAB—*Anilika, khattanitha*; KUMAUN—*Amelda, tipatia*; NEPAL—*Zolaomil*; BHUTAN—*Lunglubo*; MUNDARI—*Piri jojo, pusiganju, husuki*; SANTAL—*Tandi chatomarak*; ASSAM—*Changeritenga, tengeshitenga*; LUSHAI—*Siakthur*.

A small annual or perennial, procumbent or more or less erect herb, 6-25 cm. high, found throughout the warmer parts of India ascending up to an altitude of 3,000 m. in North-West Himalayas. Leaves few, palmately 3-foliolate: leaflets entire, roundly obovate; flowers yellow, axillary, sub-umbellate; capsules cylindrical, tomentose; seeds dark brown, numerous, broadly ovoid, transversely striate.

O. corniculata is a very common weed in cultivated and fallow lands, gardens and waste lands, particularly in moist and shady localities. It spreads rapidly

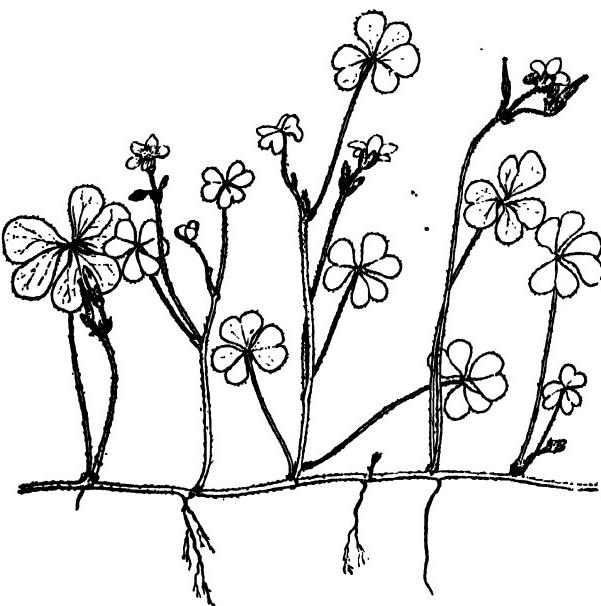


FIG. 78—OXALIS CORNICULATA—FLOWERING AND FRUITING BRANCHES

by means of numerous small underground tubers. Often it is a troublesome weed difficult to eradicate, but can be kept under control by frequent hoeing and intercultivation. In tea estates it forms a useful constituent of mixed cover, protecting soil from erosion. It can also be used as green manure, as it contains appreciable quantities of organic matter, nitrogen, potash and phosphoric acid [Puttarudriah, *Mysore Agric. J.*, 1956, **31**, 146; Edwards & Srivastava, *Allahabad Fmr.*, 1954, **28**(3), 86; Mudaliar & Rao, 127; Peradeniya Manual, No. 7, 1951; Joachim & Panditsekere, *Trop. Agriculturist*, 1930, **74**, 277].

The leaves of the plant are pleasantly acid and refreshing, and are eaten both raw as a salad and cooked as a pot-herb; they are also used for making sandwiches, chutneys and pickles. They are injurious if eaten in excess. The plants, if eaten by dairy cows, cause difficulty in churning the cream to butter. The seeds of the plant are eaten in times of famine [Santapau, *Rec. bot. Surv. India*, 1953, **16**(1), 35; Burkill, II, 1616; Williams, 396; Mayuranathan, 57; Bhargava, *J. Bombay nat. Hist. Soc.*, 1959, **56**, 26; Forsyth, *Bull. Minist. Agric., Lond.*, No. 161, 1954, 102].

Leaves are a good source of vitamin C (125 mg./100 g.) and carotene (3.6 mg./100 g.); they are rich in calcium (5.6%, dry material) but the entire amount is unavailable to the system because of the high content of oxalates (12%, dry material). The leaves and stem contain tartaric and citric acids; stems contain also malic acid. A crystalline principle (m.p. 103–04°) which produces fatal hypoglycemic convulsions in rabbits has been isolated from the plant (Basu *et al.*, *J. Indian chem. Soc.*, 1947, **24**, 358; Lengar & Rau, *Ann. Biochem.*, 1952, **12**, 41; Govindarajan & Sreenivasaya, *Curr. Sci.*, 1951, **20**, 43; *Chem. Abstr.*, 1952, **46**, 1219).

An aqueous extract of the plant shows activity against *Micrococcus pyogenes* var. *aureus*. Expressed juice of the entire plant shows activity against Gram-positive bacteria. In Australia, the plant is suspected of causing sheep mortalities with symptoms of staggering and trembling (George *et al.*, *J. sci. industr. Res.*, 1947, **6B**, 42; Nickell, *Econ. Bot.*, 1959, **13**, 281; Webb, *Bull. Coun. sci. industr. Res. Aust.*, No. 232, 1948, 123).

The plant possesses astringent, vermifuge, emmenagogue and antiseptic properties. Fresh juice of the plant cures dyspepsia, piles, anaemia and tympanitis. The leaves of the plant are considered cooling,

refrigerant, stomachic, antiscorbutic and appetizing. They are used in fevers, dysentery, scurvy and biliousness, and for removing corns, warts and other excrescences of the skin. An infusion of leaves is used to remove opacities of the cornea; it is dropped into sore eyes for itching lids. Leaf juice is also given to counteract the intoxication produced by the seeds of *Datura*. A decoction of leaves is used as a gargle (Roi, 377; Lewis, 75; Kirt. & Basu, I, 437–38; Nadkarni, I, 890; Chopra, 1958, 598, 681; Burkill, II, 1616; Mooss, 102).

O. latifolia H.B. & K.

Calder, *Rec. bot. Surv. India*, 1919, **6**(8), 335, 341.

ORAON—*Unk arxa*; DELHI—*Khatmitthi*, *khat-mandari*.

A perennial, stemless herb, 15–25 cm. high, native of Mexico, found naturalized in North-West Himalayas, Chota Nagpur (Ranchi), Assam, Peninsular India, Palni hills and Khandala (western ghats). Bulb ovate; leaves trifoliolate: leaflets broadly deltoid; flowers violet, in umbels.

O. latifolia is considered to be an efficient soil cover in tea estates in Ceylon, particularly during rains. The leaves and bulbs can also be used as green manure as they contain sufficient quantities of nitrogen, potash and phosphoric acid. In Nilgiris, however, it is a troublesome weed in potato fields. Application of butyl ester of 2,4-D at 2.27 kg. and Triherbide NIX at 13.5 kg./ha. proved to be effective



FIG. 79—OXALIS LATIFOLIA

OXALIS

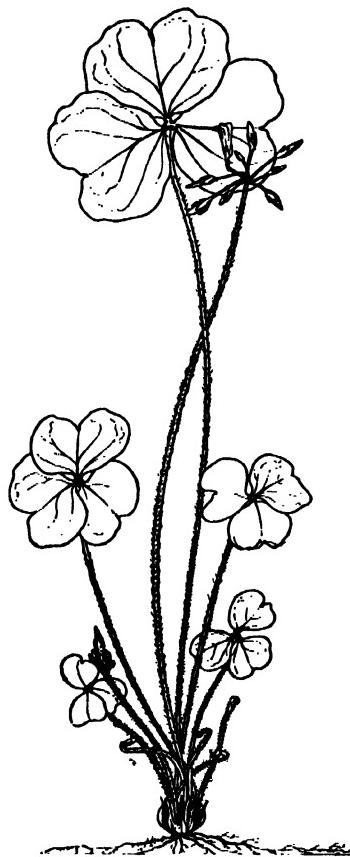


FIG. 80—*OXALIS MARTIANA*

in killing the aerial portions, while application of sodium 2,4-D and MCPA (3.35 kg./ha.) retarded the regeneration of the weeds from underground bulbs (Peradeniya Manual, No. 7, 1951; Joachim & Panditsekere, *Trop. Agriculturist*, 1930, **74**, 277; Narayanan & Meenakshisundaram, *Madras agric. J.*, 1958, **45**, 1).

The plant is used by the Oraons as a soporific (Bressers, 23).

O. martiana Zucc. syn. *O. corymbosa* DC.

Calder, *Rec. bot. Surv. India*, 1919, **6**(8), 337, 341.

TAM.—*Peria-puliyarai*.

DEL.III—*Khatmitthi*; LAKHIMPUR—*Tenga se tenga*.

A perennial herb, 23–25 cm. high, native of America, naturalized in moist and shady places in temperate parts of India, including Delhi, Mungpoo and Dibrugarh in N. India and Shevaroy and Palni hills in S. India. Bulb globose; leaves trifoliolate: leaflets broadly obcordate with a narrow sinus; flowers violet in umbelliform cymes.

The tubers have a pleasant flavour and are eaten in Lakhimpur. The leaves are sometimes used as a substitute for tamarind in Java. The plant is reported to be used medicinally in Hawaii [Carter & Carter, *Rec. bot. Surv. India*, 1921, **6**(9), 386; Burkill, II, 1616; Neal, 415].

The plant is used for edging in gardens. On steep slopes, it serves as a useful check for soil erosion. Leaves and bulbs of the plant constitute a very good green manure. Analysis of the fresh material gave the following values: moisture, 74.4; nitrogen, 0.7; lime (CaO), 0.41; potash (K₂O), 0.98; and phosphoric acid (P₂O₅), 0.18% (Williams & Williams, 242; Macmillan, 451; Joachim & Panditsekere, *Trop. Agriculturist*, 1930, **74**, 277).

Oxen—see **Livestock** (With India, VI, suppl.)

Oxybaphus—see **Mirabilis**

OXYRIA Hill (*Polygonaceae*)

D.E.P., V, 674; Fl. Br. Ind., V, 58; Blatter, II, Pl. 55, Fig. 8.

A genus of perennial herbs distributed in the alpine and arctic regions of the northern hemisphere. One species occurs in India.

O. digyna Hill (PUNJAB—*Amlu, chohahak*) is a glabrous, succulent herb with rounded, cordate or reniform leaves, which are mostly radical, and panicles of greenish or reddish flowers found in the Himalayas from Kashmir to Sikkim, in the alpine region at altitudes of 3,000–6,000 m. The plant is well adapted for rockery and may be propagated by division or by seeds (Bailey & Bailey, 525).

The leaves of the plant have an agreeable acidic taste like those of sorrel (*Oxalis* sp.) and are consumed as vegetable and salad or used in the preparation of chutneys. The herb is credited with anti-scorbutic and refrigerant properties (Medsgær, 140; Chittenden, III, 1462; Kirt. & Basu, III, 2111).

OXYSTELMA R. Br. (*Asclepiadaceae*)

D.E.P., V, 675; Fl. Br. Ind., IV, 17.

A genus of herbs distributed in tropics and subtropics of the world, but mostly confined to tropical Asia and Africa. Only a single species occurs in India.

O. secamone (Linn.) Karst. syn. *O. esculentum* R. Br. (HINDI, BENG. & ORIYA—*Dudhialata*; MAR.—*Dudhani*; GUJ.—*Jaldudhi*; TEL.—*Dudipala*; TAM.—*Usippalai*; KAN.—*Dugdhike*) is a slender, laticiferous climber, with lanceolate leaves, white or pink flowers



FIG. 81—OXYTELMA SECAMONE—FLOWERING AND FRUITING BRANCH

and green, glabrous, ovoid-lanceolate follicles, 4–7 cm. long, found in hedges near water courses throughout the plains and lower hills of India.

The flowers, fruits and leaves are reported to be eaten in times of scarcity and roots and leaves furnish fodder in famine areas. The herb is reported to possess antiseptic, depurative and galactagogue properties. A decoction of it is used as a gargle in infections of throat and mouth. The latex is bitter and said to have marked antiperiodic action. It is reported to be collected and dried and used as vulnerary. Fresh roots are prescribed in jaundice (Kirt. & Basu, III, 1605; Chopra, 1958, 598; Crevost & Petelot, *Bull. econ. Indoch.*, 1934, 37, 512).

OXYTENANTHERA Munro (*Gramineae*)

D.E.P., V, 675; C.P., 103; Fl. Br. Ind., VII, 400.

A genus of bamboos distributed chiefly in tropical Asia and Africa. Five species are found in India.

O. bourdillonii Gamble (TAM.—*Ponnungil*; MAL.—*Arambu*), a straggling bamboo, up to 9 m. in height, with long internodes, up to 5.0 cm. in diam., and forming open clumps, is found in the hills of Kerala at altitudes of 900–1,500 m. It is used for making combs, etc., and the internodes have been employed to carry maps (Rama Rao, 447).

O. monadelpha (Thw.) Alston syn. *O. thwaitesii* Gamble (Fl. Br. Ind.), non-Munro is a small, gregarious, reed-like, ornamental bamboo, with culms, 3–3.6 m. in height and c. 2.5 cm. in diam., found in the western ghats from Bababudan hills in Mysore southwards to Travancore hills at altitudes of 1,050–1,800 m.; it has also been recorded from hills of Kurnool. It is suitable for fencing, thatching and basket making (Bourdillon, 352; Gamble, 750).

O. nigrociliata Munro syn. *O. auriculata* Prain; *Gigantochloa auriculata* Kurz; *Bambusa auriculata* Kurz (BENG.—*Kalia*; ORIYA—*Bolanji*; GARO HILLS—*Washut*; ANDAMANS—*Podah*) is a densely tufted bamboo, with culms, up to 1.5 m. in height and 10 cm. in diam., sometimes striped with yellow streaks found in Garo hills in Assam, Orissa and Andaman Islands. It is used for building huts and for fishing stakes, baskets and mats. It is said to be available in large quantities and considered suitable for paper pulp. Analysis of the oven-dried bamboo gave: pentosans, 17.41; lignin, 27.09; cellulose, 66.72; hot water solubles, 3.39; ash, 1.95; and silica, 1.42%. The yield of bleached pulp on air dry material was 42.2% (Parkinson, 271; Trotter, 1940, 240, 345; Rodger, 84; Bhargava, *Indian For. Bull.*, N.S., No. 129, 1945).

O. ritcheyi Blatter & McCann syn. *O. monostigma* Beddome (MAR.—*Huda, mangam, tandali*; KAN.—*Choua, chiwa, garte*) is a medium-sized bamboo with almost solid culms, up to 9 m. in height and 3.8 cm. in diam., found from Konkan and Ahmadnagar southwards to Anaimalai hills; it is also often cultivated. It is a light demander and in the western ghats is generally found on tops of ridges and hills. It is used for fences, punt poles, walking sticks, umbrella handles and baskets (Kadambi, *Indian For.*, 1949, 75, 289; Rama Rao, 447; Trotter, 1940, 240; 1944, 228).

O. stocksii Munro (SOUTH-WEST INDIA—*Chivari, konda, mes, oor-sheme, pannangi*) is a medium-sized bamboo with culms, up to 9 m. in height and 3.8 cm. in diam., found in Konkan and N. Kanara, but rare in the ghats; it is commonly cultivated in the coastal

OXYTENANTHERA

villages. This bamboo is mostly confined to the banks of streams, and requires a well-drained deep loamy soil. The culms are strong with only a small hollow and are used for construction purposes, punt poles, umbrella handles and baskets (Blatter & McCann, 285).

OXYTROPIS DC. (*Leguminosae*; *Papilionaceae*)

D.E.P., V, 676; Fl. Br. Ind., II, 139; Ali, *Phyton*, 1959, 8 (1 & 2), 49.

A genus of herbaceous perennials spread throughout the north temperate zone, with about 13 species distributed in India, some of them occurring at high altitudes up to 5,250 m. in the Himalayas.

O. microphylla DC. (LADAKH-Niargal), an erect, tufted, stemless herb with a woody rootstock, 7.5–22.5 cm. high, is found growing in the alpine regions of western Himalayas and Sikkim, between altitudes of 3,350–4,900 m. Leaves 3.8–7.5 cm. long, with crowded leaflets; flowers purple, in heads. The plant is reported to be browsed by yaks and sheep.

O. mollis Royle ex Benth. syn. *O. thomsonii* Benth., a plant of similar habit as above with leaves, 10.0–15.0 cm. long, is found in the western Himalayas in Lahul, Ladakh and Kashmir, as well as in Nepal and Sikkim, at altitudes of 2,100–4,500 m. It has been reported from Sikkim that imported merino rams and their hybrid progeny after grazing on these plants were almost completely wiped out, as also imported horses. The local sheep, however, remained either immune to it or refused to eat it. It has been found that presence of a large amount of oxalic acid (4.3% on dry matter basis) has been responsible for the death of the animals (Siddiqui & Basha, *Indian J. Pharm.*, 1944, 6, 83).

OYSTERS [Phylum *Mollusca*, class *Lamellibranchia* (*Pelecypoda* or *Bivalvia*)]

D.E.P., V, 676; VI (1), 118–122; C.P., 557; Wlth India—Raw Materials, VI, 397.

Oysters are bivalved (two-shelled) soft-bodied molluscs, mostly marine or estuarine in habit. They occur in all tropical seas, mainly between tidal levels or in shallow waters near the estuaries. True oysters are included in the family *Ostreidae* and differ from most other bivalves in the absence of a byssus and foot and the presence of a single, centrally placed adductor muscle. Many other marine bivalves, including Pearl-oyster and Windowpane Oyster, though

fundamentally different from true oysters, are also popularly called oysters. As articles of diet, medicine and trade, oysters are of great economic importance [Gravely, *Bull. Madras Govt. Mus.*, N.S., 1941, 1; Satyamurti, *ibid.*, 1956, 1(2), pt 7].

EDIBLE OYSTERS

Edible oysters, originally included under *Ostrea* Linn. (*Ostreidae*) mainly on the basis of shell characters of the adults, have subsequently been reclassified into three genera, viz. *Ostrea* Linn., *Crassostrea* Sacco and *Pycnodonta* Sowerby, based both on their larval and adult characters. Of these the first is larviparous and the other two are oviparous. Genus *Crassostrea* is common in India, whereas the occurrence of the other two is doubtful. The important species of edible oysters occurring in Indian waters are the Backwater Oyster, *Crassostrea madrasensis* (Preston), the Giant Oyster, *C. gryphoides* (Newton & Smith), the Rock Oyster, *C. cucullata* (Born), and the Disc Oyster, *C. discoidea* (Gould).

C. madrasensis commonly occurs in backwaters and estuaries all along the east coast, but on the west coast it is confined only to the southern regions; it is particularly abundant in Ennur and Pulicat areas near Madras, in Sonapur backwaters in Orissa and in the Vembanad lake in Kerala. It occurs also under purely marine conditions, where its growth is stunted. The high tolerance of the species to changes in salinity renders its cultivation easy; it generally grows to marketable size in about two years. The valves are fairly thin and have a foliaceous texture; the inner margin and the muscle scars are deep purplish. The hinge region is narrow and sometimes elevated.

C. gryphoides is found to inhabit the muddy creeks and bays in Kutch, Dwaraka, Porbandar, Bombay, Alibagh, Ratnagiri, Jaytapur, Malwan, Vengurla, Karwar, Honavar and their vicinities along the west coast, and in the deltaic area of the Ganges in West Bengal. It has a large, elongated shell, solid in build and narrow in front but fairly broad behind. This oyster attains full growth in three to four years.

C. cucullata is the common rock oyster of India, widely distributed in the intertidal rocky areas along both the east and west coasts. It is oval or trigonal in shape. The valves are thick and slightly crenulated or plaited at the edges and their inner margins are denticulated with a moderately long hinge.



FIG. 82—SHELL OF GIANT OYSTER—CRASSOSTREA GRYPHOIDES ($\times 1/3$)

C. discoidea occurs abundantly in fairly deep waters of the littoral zone of Dwaraka, Bombay and Jaytapur along the west coast. It is flat and more or less orbicular in shape; marginal denticulations on the valves are absent.

C. crista-galli (Linn.), *C. cornucopia* (Chemnitz), *C. glomerata* (Gould) and *C. belcheri* (Sowerby) are a few other edible species recorded from India, but they are of no commercial importance.

Oyster farming—Oysters are prolific breeders and the same individual behaves as male or female, producing sperms or ova, at different times; functional hermaphrodites are also occasionally met with. The oysters functioning as females are capable of producing millions of minute eggs in a breeding season and the reproduction is either of larviparous or oviparous type, without any essential difference in their life-history stages. In larviparous type of reproduction the eggs are discharged inside the brood chamber, formed by the gills and two folds of the mantle, and the fertilization is effected internally, spermatozoids entering the brood chamber along with the current of water. The zygotes develop into larvae which are discharged into the surrounding

water. In oviparous type of reproduction, on the other hand, both ova and sperms are discharged directly into the surrounding water where fertilization takes place. The larvae, in both cases, are equivalve to begin with, but during growth the lower valve becomes larger than the upper valve. The larva swims freely in water and at the end of the free-swimming stage, lasting for two weeks or longer, it descends to the bottom, fixes or 'sets' itself to a suitable substratum by a valve and metamorphoses into a juvenile oyster, which remains permanently attached. After setting is accomplished, the young oyster is known as spat. The chances of all larvae setting as spat are remote, because of the abundance of natural enemies, generally unsuitable environmental conditions, non-availability of requisite food organisms and suitable substrata.

Oyster farming is practised in many countries and the important operations for the culture of these animals include care of the beds, securing setting of the larvae, and transplanting and conditioning the oysters for the market. Farming grounds are ordinarily maintained in the vicinity of natural beds. The care of the farms consists in hardening the bottom and cleaning away old shells, debris and natural enemies. When the larvae are ready to set, various materials, usually called culch, are placed in the cleaned beds to provide substratum for setting of larvae. Lime-coated roofing tiles, bamboo twigs and branches, dead shells of oysters, scallops, stones, discarded cardboards from packing cases pretreated with cement coating, roots of mangroves and brush wood are commonly used for the purpose. They are suspended from scaffoldings, stakes, floating rafts,



FIG. 83—ROCK OYSTER—CRASSOSTREA CUCULLATA : (right) WITH UPPER SHELL AND MANTLE REMOVED ($\times 1$)

OYSTERS

etc., in shallow waters at a depth of one or two metres and have proved quite effective. At Ennur and Pulicat near Madras, where the oyster beds are under State control, dead oyster shells are thrown broadcast over the region to enable the spat to settle on clean culch.

Young oysters are transplanted singly in areas having a congenial environment and sufficient food material; this not only stimulates growth of the oysters but also ensures better shape as compared to the animals growing under natural crowded conditions. The final stage of oyster culture consists of fattening the animals for the market. This is achieved by transferring the oysters to special beds where they are allowed to grow to the required size. Usually after 3–5 years the oyster attains the marketable size. In France, oysters are fattened and rendered green in claires or ponds in which a rich growth of diatoms is cultivated.

Although Indian waters provide a very favourable ground for oyster farming, it is not practised on any appreciable scale because of the low demand for the animals: oysters do not constitute an article of regular Indian diet and are consumed mostly by the poorer classes in coastal areas. In the vicinity of Bombay a sort of culture is attempted in which young oysters collected from natural beds are spread on hardened low-lying tidal flats and taken care of till they attain marketable size. The oysters can stand exposure out of water for a long time and, as in Japan, oyster culture in India on a large scale may prove to be a profitable industry (*Encyclopaedia Britannica*, XVI, 1001; Yonge, 15; Annandale & Kemp, *Mem. Indian Mus.*, 1916, 5, 348; Awati & Rai, *Indian zool. Mem.*, 1931, 3; Moses, *J. Bombay nat. Hist. Soc.*, 1927–28, 32, 548; Rai, *ibid.*, 1928–29, 33, 893; Korringa, *Quart. Rev. Biol.*, 1952, 27, 256, 339; Orton, 1–211; Hornell, 58; Rao, *Proc. Indian Acad. Sci.*, 1956, 44B, 332; Rao, *Souvenir, Central Marine Fisheries Research Station, Mandapam*, 1958, 56; Rao & Nayar, *Indian J. Fish.*, 1956, 3, 231).

Chemical composition—Among the sea foods, oysters are considered very delicious and are widely consumed raw or cooked. The flesh of oysters is nutritious and is stated to have a general tonic effect when included in the regular diet. It is a good source of vitamins of the B group, vitamin A, and some of the essential minerals, and contains appreciable amounts of protein. The chemical composition of oyster flesh varies over a wide range depending upon

the species, the place of origin, and the season. Analysis of edible portion (5.0–17.4%) of the back-water oyster (from Ennur) collected during different seasons gave the following values: moisture, 76.7–85.0; protein, 5.7–13.3; fat, 1.4–3.1; mineral matter, 0.5–2.1; glycogen, 0.4–5.8; calcium, 0.04–0.39; and phosphorus, 0.1–0.2%; iron, 2.5–29.6 mg.; and copper, 1.4–7.7 mg./100 g. (Tressler & Lemon, 572–74; Venkataraman & Chari, *Indian J. med. Res.*, 1951, 39, 533).

Oyster shells consist mainly of calcium carbonate and are used for the manufacture of lime. They are employed in U.S.A. as calcium supplement in poultry feeds (Tressler & Lemon, 574; Morrison, 99).

PEARL-OYSTERS

Pearl-oysters are all marine and belong to a single genus, *Pinctada* Röding (Pteriidae). Five distinct species, viz. *Pinctada vulgaris* (Schumacher), *P. margaritifera* (Linn.), *P. chemnitzi* (Philippi), *P. anomioidea* (Reeve) and *P. atropurpurca* (Dunker) are known to occur in Indian waters.

Pearl-oysters possess a straight long hinge uniting the two valves, the lower valve being a little deeper than the upper. The shell at either end is distinctly marked off from the rest into two small ear regions, one anterior and the other posterior in relation to the hinge. Unlike the edible oyster, where one of the valves is firmly fixed to a substratum, pearl-oyster has both the valves free, a bunch of threads known as the byssus, arising from the basal region of the foot, serving to anchor the animal. If the pearl-oyster by any chance loses its anchorage, it secrets a fresh byssus for fixation. The internal surface of the valves is of a brilliant lustre, which is unrivalled by that of any other shell and raises their commercial value. The arrangement of internal organs in a pearl-oyster is the same as in the edible oyster, except that a much reduced foot is found in the former but not in the latter.

P. vulgaris is the common pearl-oyster found on the pearl banks off Tuticorin coast in the Gulf of Manaar on ridges of rocks or dead coral formation and extending all along the east coast from Kilakarai to Kanniyakumari at depths of about 18 m., and in the Palk Bay on submerged objects at the muddy bottom and in the Gulf of Kutch on the intertidal reefs. Its range of distribution extends over the Red Sea, Persian Gulf, Indian Ocean and Pacific Ocean. The hinge is broad with a small tooth-like thickening in front of the ligamental area. The valves

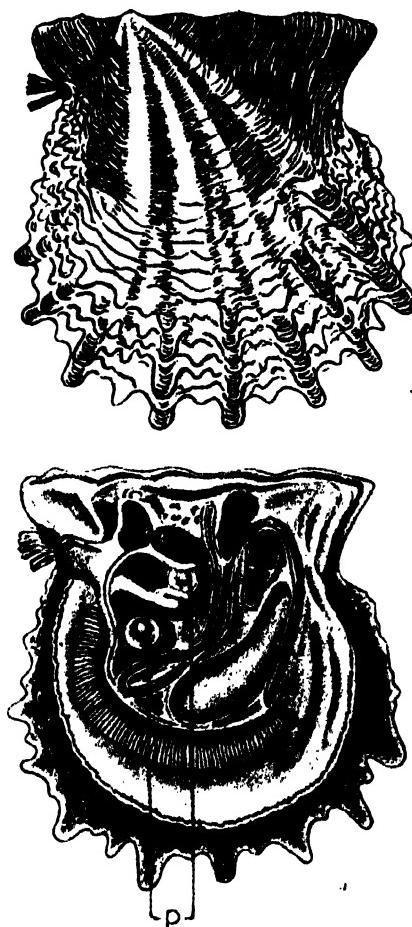


FIG. 84—PEARL-OYSTER—*PINCTADA VULGARIS* : (lower) INSIDE VIEW WITH PEARLS (P) IN SITU (X)

are convex when viewed from above ; their surface is fairly smooth with concentric lines of growth. The anterior ear region is well formed and the posterior one is usually small. The non-nacreous border often presents alternating dark and light bands and the general colouration is reddish brown. The younger shells have marginal thin, flat, radiating projections. The shells grow to c. 8 cm. in height. This species produces the world famous Orient or Lingah pearl shell and is the mainstay of the pearl fisheries of Indian waters.

P. margaritifera occurs but sparsely along the Indian coasts although it is widely distributed, supporting rich fisheries in some parts of the Pacific region, where the oyster is harvested for the sake of the shell or mother-of-pearl. The interior margin of the valves is dark with a smoky hue ; the shell is,

therefore, popularly known in commerce as the Black-lip.

P. chemnitzi is frequently found along with *P. vulgaris* in the pearl banks off the Gulf of Manaar. Its range of distribution extends from the Indian Ocean to the Central Pacific. In general contour the species resembles *P. vulgaris* except for the posterior ear region which is well developed. It grows up to c. 10 cm. in height. *P. anomioides* is spread over the Indo-Pacific region and has been recorded from Bombay and the Andamans in the Indian territory. The shell is thin and the hinge is without a tooth. The maximum size, attained by this species, is much smaller than that of *P. vulgaris*. *P. atropurpurea* is distributed widely in the Indo-Pacific region. It is closely related to *P. anomioides*. The shell is thin, translucent and copper coloured ; anterior tooth of the hinge is but poorly developed.

The pearl fisheries of the Gulf of Manaar have been exploited from time immemorial and the fishing rights, as far as known from historical records, passed in succession from one ruling power to another. Of the *pars* or extensive pearl banks in the region, the northern and the southernmost ones at present are barren, and those of the central group, at a distance of 11–13 km. into the sea from the coastline between Kayalpatnam and Vaippar alone remain productive ; the fisheries are now being operated from Tuticorin as the base and some millions of oysters are taken out of the sea by skilled divers during the summer season. Details regarding pearl fisheries are given under *Fish and Fisheries* (With India—Raw Materials, IV, suppl., 125).

PEARLS (SANS.—*Mukta, marakata* ; HINDI—*Moti* ; BENG.—*Mukta* ; GUJ.—*Mutti* ; TEL.—*Muthiamu* ; TAMIL.—*Muthu, muthuchippi* ; MAL.—*Muti, mutya, mutiyara lulu*) are calcareous concretions, formed as protection against the irritation caused by foreign objects, either bits of gravel or minute parasites, which lodge inside between the mantle and the shell of the animal. The common parasite found in pearl-oysters of India and Ceylon is the larval cyst of the tapeworm, *Tentacularia unionifactor* (Herdman & Hornell). A fold of soft tissue envelops the foreign particle and deposits layer after layer of nacre (mother-of-pearl) on it. Although pearls occur in a variety of molluscs, only those having a good lustre are valued as gems.

True wild pearls may occur in spherical or irregular shapes in a free state, or may be found attached to the shell as 'demi' or 'blister' pearls, which may have

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to be cut out from the shell. The value of pearls varies with their size, weight, shape, lustre, colour and perfection. In South India the merchants employ a nest of ten colanders (brass sieves of different types with perforations varying in number from 20 to 1000) for grading pearls. After grading they are further classified according to their shape, weight and lustre. Ten grades of pearls are recognized in India, viz. *Anie* (perfect in shape, lustre and weight), *Vadivu* (not so perfect as *Anie*), *Anatharie* (failing in shape or lustre), *Masagoe* (failing both in shape and lustre), *Kallipu* (rejected, inferior to *Masagoe* in both aspects), *Korower* (a double pearl), *Peesal* (a cluster of more than two), *Mandangoe* (folded or bent pearl), *Kural* (very misshapen and small) and *Thul* (seed pearls or powders). The market price of a pearl increases as the square of its weight or size.

Pearl culture, as practised in Japan, involves inducement of the oyster to secrete pearly substance round a deliberately introduced foreign body of the nature of a shell-bead. This extraneous object and a bit of the graft tissue from the most actively nacre secreting region of the mantle are introduced into the soft tissue of the oyster by a delicate operation without much injury to the soft body, and the treated oysters are taken proper care of from one to three years till the process of pearl formation is completed. In 1938-39 at Krusadai near Pamban in the Gulf of Manaar first experiments at grafting beads of mother-of-pearl into live oysters were tried with initial success of producing free pearls. These experiments further revealed that in the warmer waters of the Gulf of Manaar the production of cultured pearls took lesser time than in the Japanese waters. Hence pearl culture in India even on a small scale may prove to be a promising industry (*Encyclopaedia Britannica*, XVII, 420-23; Prashad & Bhaduri, *Rec. Indian Mus.*, 1933, 35, 167; Rao, *Souvenir, Central Marine Fisheries Research Station, Mandapam*, 1958, 58; Hornell, *J. Asiatic Soc., Beng.*, N.S., 1922, 18, 213; *Madras Fish. Bull.* No. 16, 1922; Hornell, 52; Awati, *J. Bombay nat. Hist. Soc.*, 1927-28, 32, 524; Gokhale *et al.*, *ibid.*, 1953-54, 52, 124; Jameson, *Proc. zool. Soc. Lond.*, 1912, pt 1, 260; *Industry, Calcutta*, 1952, 43, 476).

Pearls are composed of many tiny overlapping plates of nacreous material. The nacre consists of prismatic pseudohexagonal aragonite crystals (a polymorph of calcium carbonate) held together by conchiolin ($C_{32}H_{48}N_2O_{11}$), a horny scleroprotein of the keratin type. Pearls contain 90-92% of calcium

carbonate (as aragonite), 4-6% of organic matter and 2-4% of water, their relative proportion varying with the species, the position of pearl within the shell and other factors. The density of natural pearls ranges from 2.60 to 2.78. The beautiful lustre of the pearls is due to a combination of two optical effects, viz. the breaking up of light into minute spectra by diffraction, due to the irregular edges of the overlapping crystal plates of aragonite and the interference of light at thin films given by these platelets. The delicate shades of colour of the different pearls have been ascribed to the nature of waters which the mollusc inhabits (*McGraw-Hill Encyclopedia of Science and Technology*, IX, 606-07; Webster, I, 374-79).

Cultured pearls, though similar in their properties to the natural pearls, do not fetch the same price in the market. Natural pearls can be distinguished from cultured pearls only with great difficulty. For this purpose pearls may have to be subjected to examination by X-rays, powerful electromagnets or endoscope (Webster, I, 408-23).

In an experiment to study whether the chemical constituents have any role in promoting or affecting the formation of pearls, the meats from pearl-oysters having fairly good-sized pearls (pea-sized), those with seed pearls (of the size of mustard or sand granules), and those without any pearls were examined. They did not differ much in composition. However, the iron content of the meat without any pearls was nearly seven times that of the meat having big pearls. The composition of the meat was as follows (dry basis): nitrogen, 8.90-10.11; fat, 3.72-3.83; ash, 13.65-14.48; calcium (CaO), 2.00-2.69; and phosphorus (P_2O_5), 0.93-1.25%; iron, 15.80-102.45 mg./100 g. (Venkataraman & Chari, *J. sci. industr. Res.*, 1956, 15C, 212).

Besides natural and cultured pearls, imitation pearls are very popular as substitutes and their manufacture has become a world-wide industry. Small opalescent and easily fusible hollow glass or plastic beads are generally filled with a highly lustrous substance like the fish-scale essence, in a concentrated form, and the ends sealed off with wax. These beads are further coated with the pearl essence, and sometimes given coloured finishing. Imitation pearls are easily identified by an examination of the surface with a lens; they do not show the serrated structure of a real pearl. Further their density is usually higher than natural or cultured pearls, ranging between 2.85 and 3.18 (Webster, I, 423-27).

The shell consists of three layers in general, of which the innermost is the mother-of-pearl and is built up of tiny overlapping scale-like deposits. Pearl-oyster shells of fine texture are fished for mother-of-pearl in various parts of the world, especially in Australia and the Philippines, for the manufacture of buttons and other decorative articles, rather than for the pearls. The shells of the Indian species are not sufficiently thick for this purpose.

Pearls are used as ornaments, in inlaying work and in other works of art. They have also been used in medicine by the Ayurvedic and Unani physicians from ancient times. In general, pearls are considered to possess antacid and tonic properties and are mostly used in the form of pearl ash (*Mukta Bhasma*), obtained as a result of powdering or calcining the pearls. In combination with other medicines they are prescribed in tuberculosis, jaundice, dyspepsia and urinary complaints.

OTHER OYSTERS

Oysters of several other kinds include a large number of small groups of bivalves living in varied habitats and having particularly nothing in common among them. They are the Windowpane oysters, the Finger Oysters, the Hammer Oysters, the Thorny Oysters and the Freshwater Oysters.

Windowpane oyster or Window shell, *Placuna placenta* Linn. (*Anomiidae*), inhabits the muddy bottom areas of the bays, harbours, coastal backwaters and estuaries which are normally subject to influx of freshwater. The shells of this species are flat, thin, translucent, orbicular or suborbicular, and slightly inequivalve. They are pearly white with a shade of pink or yellow. The horny layer which covers the outer surface of the valves is extremely thin and almost transparent. The shells grow as big as 15 cm. or more in width in about three years. They are used for glazing and are also employed in the manufacture

of decorative articles like lamp shades, screens, etc. Both the living and the dead shells are gathered for small, mostly misshapen, dull, lustreless pearls, called 'seed pearls', which have no value as gems, but are used in large quantities in indigenous medicine.

Windowpane oysters contribute to fisheries of minor importance at some places along the coastal regions of India. The most productive beds are in the Gulf of Kutch, especially in the Balapur area and the Rann Bay. Fishable beds of some magnitude also exist in the vicinities of Bombay and in the Corangi Bay near Kakinada in Andhra Pradesh. The Kutch fisheries used to fetch high revenue about three decades ago but have now declined materially. Fisheries of the windowpane oysters occur also in Ceylon and the Philippines.

Finger oysters or the Chinaman's finger nails, *Solen lamarckii* Chenu, *S. kempfi* Preston, *S. linearis* Spengler and *S. annandalei* Preston (*Solenidae*), occur in low-lying sandy mud flats, and in marine or brackish waters or estuarine environs under tidal influence. They are burrowing forms digging into and hiding themselves at the muddy bottom. The coastal people collect them for food and fishermen use them as bait in line fishing.

Hammer oysters (*Isognomonidae*) are represented in Indian waters by *Malleus malleus* (Linn.), *M. albus* Lam., *Vulsella vulsellula* Linn. and *Isognomon nucleus* (Lam.).

Thorny oysters, *Spondylus imperialis* Chenu and *S. layardi* Reeve (*Spondylidae*), have very elegant inequivalved shells which are often made into beautiful toys in shell-craft industries.

Freshwater oysters (*Etheriidae*) are in reality mussels and not oysters; the only freshwater oyster recorded in India belongs to the genus *Pseudomulheria* Anthony (Annandale & Kemp, *Mem. Indian Mus.*, 1916, 5, 353; Prashad, *Proc. Roy. Soc. Edinb.*, 1931, 51, 42; Hornell, 47-48, 56-58).

P

PACHYGONE Miers (*Menispermaceae*)

Fl. Br. Ind., I, 105.

A small genus of climbing shrubs distributed in Indo-Malaysian region. One species occurs in India.

P. ovata Miers ex Hook. f. & Thoms. is a lofty

scendent shrub found on the sandy sea shores of the Coromandel coast and in southern Deccan, Madras, Mysore and Andhra Pradesh. The dried fruits of the plant are said to be used as vermicide and as fish poison (Kirt. & Basu, I, 90).

PACHYLARNAX

PACHYLARNAX Dandy (*Magnoliaceae*)

Fl. Assam, I, 19.

A small genus of trees distributed in Indo-Malayan region. One species is found in India.

P. pleiocarpa Dandy (ASSAM—*Phulsopa, kothalpathia sopa*) is a large evergreen tree with rough bark, elliptic- or oblanceolate-oblong leaves and whitish yellow fragrant flowers found in Lakhimpur in Assam. The tree is suitable for planting in tea estates; propagation by transplanting 15-month old seedlings during cold weather gave the best results. The wood is even-grained, hard, takes a fine polish and is valued for cabinet work (Macalpine, *Tocklai exp. Sta. Memor.*, No. 24, 1952, 164).

PACHYRRHIZUS Rich. ex DC. (*Leguminosae*; *Papilionaceae*)

A small genus of climbing herbs with tuberous roots, originally native of tropical America, now distributed throughout the tropics of both hemispheres. One species is cultivated in India for its edible tubers.

P. erosus (Linn.) Urban syn. *P. angulatus* Rich. ex DC.; *P. bulbosus* Kurz YAM BEAN

D.E.P., VI (1), 1; Fl. Br. Ind., II, 207; Clausen, *Mem. Cornell Univ. agric. Exp. Sta.*, No. 264, 1944, Fig. 1-4.

HINDI & BENG.—*Sankalu*.

A coarse, hairy twiner, with large, fleshy tuberous roots, occasionally found cultivated in parts of Bengal, Assam, Bihar and Orissa. Tubers simple or lobed, turnip-like or elongated, variable in size, up to 30 cm. in diam.; leaves trifoliolate; leaflets large, distantly toothed; flowers in lax racemes, blue or violet; pods hairy, 8-15 cm. long, with 8-10 seeds; seeds yellow, brown or red, almost square, more or less flattened, 5-11 mm. long and 5-10 mm. broad.

The plant is a native of Mexico and Central America, but widely naturalized in various parts of the tropics, in both the hemispheres. It is cultivated widely in parts of Central America, Philippines, China, Indo-China and Indonesia. It is a perennial, as far as underground tubers are concerned, but an annual with respect to aerial portions. It is variable regarding leaf shape, size and shape of tubers and seeds. It is not much suited for cultivation in a very wet climate. It grows well on light, rich, sandy soil and can be propagated by tubers or seed. In Orissa, seeds are sown in June-July and the plants are given one or two prunings after about two months, in order to restrict vegetative growth and encourage better

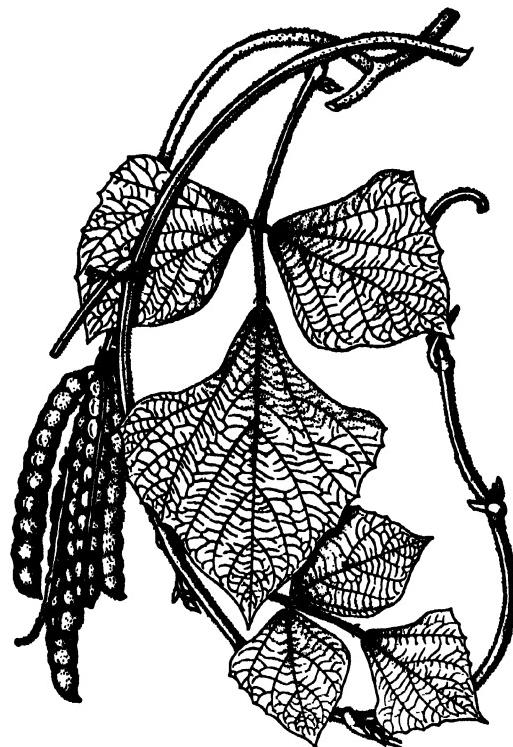


FIG. 85—PACHYRRHIZUS EROSUS—FRUITING BRANCH

tuber development. The best tubers for eating are said to be obtained from non-flowering plants; usually most of the flower buds are removed, except a few left for seed development. The turnip-like roots should be dug out before the seeds ripen, as they are then relatively tender. It is stated that they take two years to reach full size. In Orissa, the tubers are dug out from December to March. The tubers sold in Calcutta market are about 12-13 cm. in diameter and weigh from 2 to 5 kg. each; but fully developed tubers measuring c. 25 cm. in diameter and weighing about 5-18 kg. are known. In parts of Indonesia and Philippines, where it is grown on field scale, yields as high as 95 tonnes per hectare have been recorded [Clausen, *Mem. Cornell Univ. agric. Exp. Sta.*, No. 264, 1944; Gopalaswamiengar, 556; Burkhill, II, 1619; Macmillan, 282; Rattan & Sen, *Ann. Biochem.*, 1941, 1, 163; Nag *et al.*, *Trans. Bose Res. Inst.*, 1935-36, 11, 83; de Sornay, 111; Patnaik, *Indian Hort.*, 1964-65, 9(1), 13; Information from Curator, Industrial Section, Indian Museum, Calcutta].

The young tubers have a crisp, juicy and refreshing flesh and can be eaten raw or cooked; they can also be sliced and made into chips. Analysis of peeled tubers (from Bengal) gave: moisture, 82.38; protein,

1.47 ; fat, 0.09 ; starch, 9.72 ; reducing sugars, 2.17 ; non-reducing sugars, 3.03 ; fibre, 0.64 ; and ash, 0.50% ; copper, 0.43 ; iron, 1.13 ; and calcium, 16.0 mg./100 g. The vitamins present in the tubers (from Philippines) are: thiamine, 0.05 ; riboflavin, 0.02 ; niacin, 0.2 ; and ascorbic acid, 14 mg./100 g. The tubers contain adenine, arginine, choline and phytin. The juicy flesh is rich in ascorbic acid and has an antiscorbutic action on rats (Merrill, 148 : Burkill, II, 1620 ; Rattan & Sen, loc. cit. ; *Handb. Inst. Nutr. Philipp.*, No. 1, 1957, 28 ; Winton & Winton, I, 39 : II, 79 ; Nag *et al.*, loc. cit.).

The tubers are also useful as fodder. The mature tubers yield a starch of superior quality. The starch is dry to touch and insipid in taste and consists chiefly of polyhedral or semipolyhedral grains (c. 8.35 μ in diam.) showing striations (Porterfield, *Econ. Bot.*, 1951, 5, 3 ; de Sornay, 111 ; Bastin, *Bull. agric. Congo belge*, 1939, 30, 258).

The young pods can be used as vegetable, but they are reported to become poisonous as they become mature, causing diarrhoea, due to irritation of the hairs. Analysis of the edible portion (90%) of young pods (from Philippines) gave the following values: moisture, 86.4 ; protein, 2.6 ; fat, 0.3 ; carbohydrates, 10.0 ; fibre, 2.9 ; and ash, 0.7% ; calcium, 121 mg. ; phosphorus, 39 mg. ; iron, 1.3 mg. ; vitamin A, 575 I.U. ; thiamine, 0.11 mg. ; riboflavin, 0.09 mg. ; and niacin, 0.8 mg./100 g. (*Kew Bull.*, 1889, 121 ; Burkill, II, 1620 ; *Handb. Inst. Nutr. Philipp.*, No. 1, 1957, 28).

The powdered seeds are useful as insecticide and fish poison in tropical countries. They act as contact and as stomach-poisons and are reported to be highly effective against many insects such as silkworm larvae, aphids, cabbage worms, melon worms, beetles, leaf hoppers, cattle lice, etc. A process has been patented which employs ground seeds (or extracts) in various formulations with pyrethrin, for use in insecticidal sprays and dusts. It is advantageous to use defatted seeds. The leaves, stems, roots and ripe pods also show insecticidal activity ; leaves are toxic to mosquito larvae (Spickett, *Colon. Pl. Anim. Prod.*, 1955, 5, 292 ; Jacobson, 149-50 ; Chiu, *J. Sci. Fd Agric.*, 1950, 1, 276 ; *Chem. Abstr.*, 1946, 40, 163 ; 1947, 41, 1800).

The seeds on extraction with ether yield a toxic resin from which have been separated rotenone ($C_{20}H_{22}O_6$, m.p. 164°) and several new substances, viz. pachyrrhizine ($C_{19}H_{12}O_6$, m.p. 206.5-8.5°), pachyrrhizone ($C_{20}H_{11}O_7$, m.p. 272°), erosone

($C_{20}H_{16}O_6$, m.p. 218°), two crystalline principles ($C_{20}H_{12}O_6$, m.p. 242° and $C_9H_1O_5$, m.p. 360°), and pachyrrhizid (a mixture of amorphous substances variously melting up to 123°) ; most of these substances are related to rotenoids and pachyrrhizine ; erosone and pachyrrhizid are toxic to insects. Rotenone content of the seeds is generally low (c. 0.1%) but samples collected from China contained 0.5-1.0%. The seeds also contain two water-soluble amorphous saponins, pachysaponins A and B, which on hydrolysis give respectively, pachysapogenin A ($C_{30}H_{58}O_6$, m.p. 196-98°) and pachysapogenin B ($C_{23}H_{41}O_7$, m.p. 176°). Both the saponins are toxic to fish and kill them in a concentration of 1:10,000 within 15-20 minutes (Norton & Hansberry, *J. Amer. chem. Soc.*, 1945, 67, 1609 ; Norton, *ibid.*, 1943, 65, 2259 ; *Chem. Abstr.*, 1958, 52, 11033 ; 1954, 48, 10721 ; 1943, 37, 1805 ; Baker & Lynn, *J. Amer. pharm. Ass., sci. Edu.*, 1953, 42, 117 ; Shangraw & Lynn, *ibid.*, 1955, 44, 38).

The seeds are rich in proteins and oil but are believed to be poisonous when consumed by cattle or human beings : the toxic principles can be completely eliminated by extraction with boiling alcohol. They are also said to be used as laxative and vermifuge. Powdered seeds are applied for prickly heat in Java. Analysis of dried seeds gave: moisture, 6.7 ; protein, 26.2 ; fatty oil, 27.3 ; carbohydrates, 20.0 ; fibre, 7.0 ; and ash, 3.64% ; the ash has a high content of phosphorus (P_2O_5 , 33%) and calcium (CaO , 13%). The fatty oil has the following characteristics: sp. gr.²¹, 0.914 ; n^{20} , 1.4673 ; sap. val., 196.7 ; iod. val., 85.3 ; acid val., 1.1 ; R.M. val., 2.71 ; and unsapon. matter, 2.3% ; the component fatty acids are saturated, 37.6% and unsaturated (oleic and linoleic), 62.4% (Nag *et al.*, loc. cit. ; Burkill, II, 1620).

The leaves are poisonous to cattle other than horses ; they contain pachyrrhizid. Leaves and stems contain free steroids (Burkill, II, 1620 ; Simes *et al.*, *Bull. sci. industr. Res. Org. Aust.*, No. 281, 1959, 15).

The stems are said to yield a tough fibre used in Fiji in making fishing nets. The plant can be grown as green manure with advantage, as grazing animals are said to eat it most unwillingly (Burkill, II, 1620 ; Porterfield, loc. cit.).

A plant very similar to the above and often confused with it is *P. tuberosus* Spreng., a native of S. America, often cultivated for the edible tubers. This species is considered by some as a cultigen of *P. erosus* from which it differs mainly in the large, entire leaflets, whitish flowers, larger pods (25-30 cm. long) and large, flattened seeds, about 11-14 mm. long. The

PACHYRRHIZUS

tubers resemble those of *P. cerasus*, but they are larger and less hairy. The tubers yield a starch which is pure white and equal in every respect to arrowroot (*Maranta arundinaceae*) and can be used for puddings. The yield of starch is much greater than that of arrowroot. The seeds show the same insecticidal properties as those of *P. cerasus* (Kew Bull., 1889, 17, 62, 121; Buttenshaw, W. Ind. Bull., 1905, 5, 1; Bois, I, 171).

PACHYSTACHYS Nees (Acanthaceae)

Bailey, 1949, 922; Chittenden, II, 1083.

A genus of herbs or rarely shrubs, native of tropical America. One species, *P. coccinea* Nees (syn. *Jacobinia coccinea* Hiern; *Justicia coccinea* Aubl.), a very pretty glabrous shrub, 60–120 cm. high, with elliptic or ovate-lanceolate leaves and brilliant, crimson-scarlet flowers is grown in Indian gardens. It is reported to be used medicinally in Guiana. The leaves are toxic and contain traces of an alkaloid (Firminger, 408; Kirt. & Basu, III, 1896; Wehmer, II, 1144).

PACHYSTOMA Blume (Orchidaceae)

Fl. Br. Ind., V, 811; Santapau & Kapadia, J. Bombay nat. Hist. Soc., 1962, 59, 382, Pl. 46.

A small genus of orchids distributed from India through Malaysia to New Guinea. One species, *P. senile* Reichb. f. (BERAR & C.P.—*Safed mushi, kurkutti*), an erect, terrestrial orchid, 20–45 cm. high, is reported to be found in the plains of North India and also in the lower elevations of hills in North and South India.

The orchid bears rather stout rhizomes, often intimately associated with roots of grasses. It is leafless at the flowering time; the flowers are greenish white, tinged with pink or purple and are borne on racemes.

The rhizomes of the orchid are reported to be collected and sold for medicinal purposes; their exact use or properties are not known (Witt, 218).

Padauk — see *Pterocarpus*

Paddy — see *Oryza*

PAEDERIA Linn. (Rubiaceae)

A genus of shrubby climbers distributed in tropical and temperate Asia and America. Eight species occur in India.

P. foetida Linn.

D.E.P., VI (1), 2; Fl. Br. Ind., III, 195; Kirt. & Basu, Pl. 508.

SANS.—*Prasarani*; HINDI—*Gandhalī, somaraji*; BENG.—*Gandha bhadulia*; MAR.—*Hiranvel*; GUJ.—*Gandhana*; TEL.—*Savirela*; TAM.—*Penarisangai*; KAN.—*Hesarane*; MAL.—*Talanili*; ORIYA—*Gandali*.

ASSAM—*Bedoli sutta, paduri-lata*; SIKKIM & NEPAL—*Padebiri*; LEPCHA—*Takpaedrik*.

An extensive foetid climber found in the Himalayas from Dehra Dun eastwards up to an altitude of c. 1,800 m., and also in Bihar, Orissa, Bengal and Assam. Leaves ovate to lanceolate, 5.15 cm. long and 2.7 cm. broad, entire, membranous, with long petioles; flowers in scorpioid cymes, purple or violet; fruit ellipsoid, compressed, red or black.

Leaves possess tonic and astringent properties. They are sold in Calcutta markets in a fresh condition, and are used in soups and other food preparations for invalids and convalescents, particularly those suffering from bowel complaints. The foetid smell is due to the presence of a volatile principle, methyl mercaptan; this is removed to a great extent during cooking; reported presence of alkaloids is not confirmed by later investigations (Kirt. & Basu, II, 1298; Datta & Mukerji, Bull. Pharmacogn. Lab., No. 1, 1950, 61; Chopra et al., 532; Steinmetz, Quart. J. Crude Drug Res., 1961, 1, 133; Bose et al., Trans. Bose Res. Inst., 1953, 19, 77).

Almost all parts of the plant have been employed in medicine for rheumatic affections. A poultice of the leaves is applied to abdomen to relieve distension due to flatulence. The poultice is also used in herpes; it is said to afford quick relief and has the advantage of being painless and harmless to eyes. In the Philippines, boiled and mashed leaves are applied to the abdomen in cases of retention of urine; a decoction of the leaves, is reported to possess diuretic properties, and also to dissolve vesical calculi. Roots and bark are employed as emetics and the fruit is used by the hill tribes to blacken the teeth with a view to prevent toothache. The juice of the root is prescribed in piles, inflammation of spleen, and pain in the chest and liver. The species may prove helpful for eliminating poisons collected in the system due to the use of noxious substances, such as alcohol and tobacco, or due to defective metabolism. The claims made by various observers regarding the efficacy of this drug justify further clinical trials. The plant yields a strong and flexible fibre having a silky appearance (Kirt. & Basu, II, 1298; Burkill, II, 1622; Datta & Mukerji loc. cit.; Steinmetz, loc. cit.).

Leaf protein (44.6%, dry basis) shows the following amino acid make-up: arginine, 4.9; histidine, 2.1;

lysine, 3.8 ; tyrosine, 5.1 ; tryptophan, 1.9 ; phenylalanine, 6.8 ; cystine, 1.4 ; methionine, 2.1 ; threonine, 4.3 ; and valine, 7.0 g./16 g.N. Leaves are rich in carotene (3.6 mg./100 g.) and vitamin C (up to 100 mg./100 g.) (Kuppuswamy *et al.*, 232 ; Basu *et al.*, *J. Indian chem. Soc.*, 1947, **24**, 358).

P. scandens (Lour.) Merrill syn. *P. tomentosa* Blume, a climber considered by some as a synonym of *P. foetida*, is found in the eastern Himalayas and Assam. Its medicinal uses are similar to those of *P. foetida*. In Indo-China, the plant is credited with antiphlogistic properties and is said to be useful in tenesmus (Burkill, II, 1622 ; Kirt. & Basu, II, 1299).

PAEONIA Linn. (*Ranunculaceae* ; *Paoniaceae*)

A genus of ornamental herbs and undershrubs distributed in the north temperate zone, especially in the Mediterranean region and Asia. One species occurs in India.

Herbaceous peonies are preferred for ornamental purposes to the woody kinds. In delicacy of tint and fragrance they resemble the rose, the double flowered ones being more popular. They grow well in the cool climate of the hills, thriving in a deep, rich, rather moist loamy soil. The easiest method of propagation is by division of the fleshy roots (Bailey, 1947, III, 2432 ; Firminger, 632).

P. emodi Wall. ex Royle HIMALAYAN PEONY

D.E.P., VI (1), 3 ; Fl. Br. Ind., I, 30 ; Coventry, I, 19, Pl. 10.

HINDI—*Ud-salap*.

PUNJAB—*Mamekh*, *chandra* ; KASHMIR—*Mid.*

A herbaceous or a shrubby perennial with a cluster of fleshy roots, distributed in the Himalayas from Kashmir to Kuimaun at altitudes of 2,000–3,000 m. ; it is also grown for ornament in gardens on the hills. Leaves divided into distinct leaflets : segments oblong or lanceolate ; flowers showy, 7–10 cm. diam., white or red, usually solitary, sometimes in groups of 2 or 3 ; follicles ovoid with a few seeds.

The plant often occurs in gregarious patches and is reported to be abundant in Liddar valley near Pahlgam (Kashmir). The tender shoots are cooked and eaten as vegetable. The fleshy roots are used in uterine diseases, biliousness, dropsy and nervous affections ; they are also prescribed as a blood purifier for children. Excessive doses cause headache, confused vision and vomiting. The seeds are emetic and cathartic. An infusion of the dried flowers is



Bot. Surv. India

FIG. 86—PAEONIA EMOIDI—FRUITING BRANCH

given to control diarrhoea (Chopra *et al.*, 134 ; Kirt. & Basu, I, 26).

The roots of *P. emodi* are reported to contain an essential oil, with salicylaldehyde as the chief component, a fixed oil, benzoic acid and sucrose. Tubers and seeds of an allied European species, *P. officinalis* Linn., contain a toxic alkaloid which produces contraction of the renal capillaries and increases the coagulability of blood ; this species has medicinal uses similar to those of *P. emodi*. It is quite likely that *P. emodi* may contain a similar principle (*J. sci. industr. Res.*, 1961, **20A**, 300 ; Chopra *et al.*, 134).

PAJANELIA DC. (*Bignoniaceae*)

A monotypic genus distributed from India to Malaya.

P. longifolia K. Schum. syn. *P. rheedii* Wight ; *P. multijuga* DC.

D.E.P., VI (1), 4 ; Fl. Br. Ind., IV, 384.

MAR.—*Domudi* ; TAM.—*Aranthal* ; KAN.—*Alangi* ; MAL.—*Arlantha*, *paiyani*, *pajaneli*.

KHASI—*Dieng-tang-leng*, *dieng-long-oh* ; ANDAMANS—*Jhingan*.

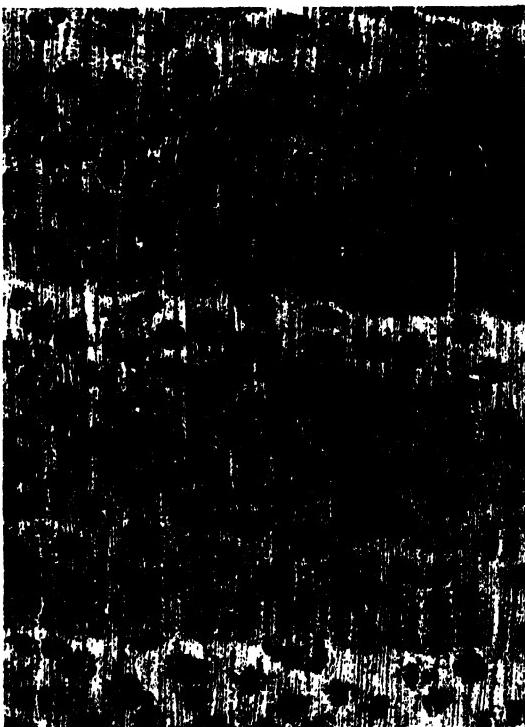
PAEONIA

A medium-sized to large deciduous tree, sometimes up to 27 m. in height and 2.7 m. in girth, found in the hills of Assam, in western ghats from N. Kanara to Travancore and in the Andaman Islands. Bark brown, rough, fissured; leaves large, imparipinnate: leaflets obliquely ovate to ovate-lanceolate; flowers in large panicles, handsome, crimson with yellowish lobes; capsules flat, 60 cm. long; seeds compressed, winged.

The wood smells like teak when freshly cut and seems to be similarly immune to termites. It is used for canoes, catamarans, house building and planking. The wood from N. Kanara is reported to be soft and light (wt., 480 kg./cu.m.); so also the wood from Burma. Gamble's description of wood from the Andaman Islands as orange brown, close-grained, hard, heavy (wt., 833 kg./cu.m.) and durable, is mistaken and is based on a specimen probably of *Afzelia* or *Intsia*. A recent examination of specimens from the Andamans and Burma showed that the wood is greyish brown, soft, light (density, 0.322–0.367), lustrous, straight-grained and coarse-textured. The tree is much grown as a support in pepper (*Piper*



FIG. 87—PAJANELIA LONGIFOLIA—FLOWERING BRANCH



F.R.I., Dehra Dun. Photo : S. S. Ghosh

FIG. 88—PAJANELIA LONGIFOLIA—TRANSVERSE SECTION OF WOOD (x10)

nigrum Linn.) plantations where it does not usually attain a height of more than 12 m. (Parkinson, 216; Talbot, II, 318; Rodger, 18; Information from F.R.I., Dehra Dun; Bourdillon, 245; Rama Rao, 298).

The plant is employed in Malaya medicinally for the same purposes as *Oroxylum indicum*. The dried stem bark yields up to 5% of a bitter, crystalline principle, pajaneclin ($C_{15}H_{10}O_5$, m.p. 237–39°), which is a fructose ester of *p*-hydroxy cinnamic acid; the latter also occurs in the free state (yield, 0.1%). Pajaneclin is also present in the root bark (Burkill, II, 1623; Kameswaramma & Seshadri, *Proc. Indian Acad. Sci.*, 1947, 25A, 43).

Palaemon — see Prawns, Shrimps and Lobsters

PALQUIUM Blanco (*Sapotaceae*)

A genus of laticiferous trees distributed from India to the central Pacific. Four species are found in India: all of them yield gutta-percha, a latex coagulum. The chief source of Gutta-percha of commerce, however, is *P. gutta* (Hook. f.) Baill. syn. *Dichopsis gutta* Benth. & Hook. f., a tree of Malayan origin,

which now grows also in Borneo, Sumatra, Philippine Islands and other tropical countries. The tree has been reported to be introduced in Lalbagh Botanic Gardens, Bangalore, and its cultivation elsewhere in India has not been recorded. Gutta-percha is a non-elastic rubber formed by coagulation of the latex obtained by tapping the tree. It is an exceedingly poor conductor of electricity and is much used for insulation purposes, mainly in the construction of submarine cables ; other uses are in the manufacture of pipes, golf balls, telephone receivers, surgical instruments and dressings, dental cements, waterproofing materials and adhesives. Gutta-percha from Indian species is in most cases mixed with resinous matter to such an extent that it is not commercially worth collecting (Hill, 146-48 ; Pearson & Brown, II, 667).

P. ellipticum (Dalz.) Baill. syn. *Dichopsis elliptica* (Dalz.) Benth. & Hook. f.

D.E.P., III, 102 ; C.P., 627 ; Fl. Br. Ind., III, 542.
MAR.—*Panchoti* ; TAM.—*Kat illupci, palvadinjan* ; KAN.—*Panchonta, hadasale* ; MAI.—*Pala, pali, chop-pala, panchendi*.

TRADE—*Pali*.

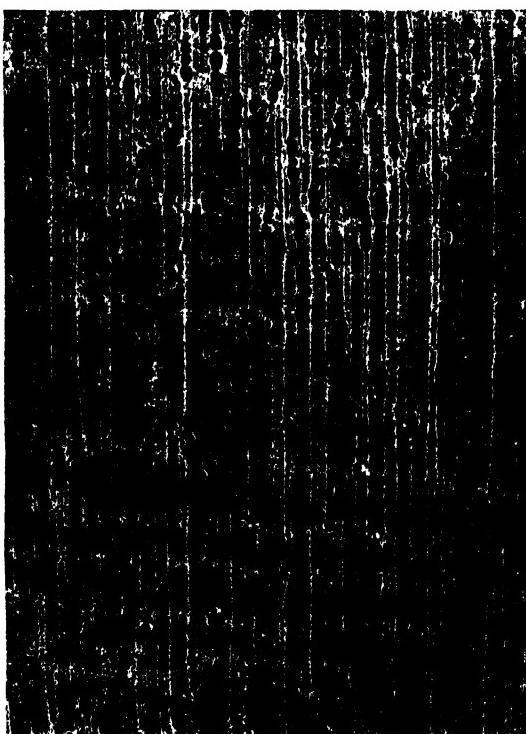
A large tree, up to c. 30 m. in height, 3.6 m. in girth and with a long, straight, but fluted hole, found in the western ghats from Bombay southwards up to an altitude of 1,200 m. Bark brown, mottled with white : leaves elliptic-obovate ; flowers white, fragrant ; berries ellipsoid, up to 3.75 cm. long, 1-seeded ; seeds brownish.

Natural regeneration of the tree is facilitated by the removal of understorey and weeding in the initial stages and drastic opening of the top canopy, amounting almost to clear felling during later stages. Artificial reproduction can be obtained by transplanting nursery or forest seedlings : basket plants have been found to succeed best. Direct sowing gives poor results. The tree does not coppice well. It is subject to white rot [*Ganoderma applanatum* (Pers.) Pat.] (Indian For., 1952, 78, 280 ; Khan, Pakist. J. Sci., 1952, 4, 65).

The tree yields light red to reddish brown wood, rather sharply defined into sapwood and heartwood in old trees. Heartwood is smooth, generally straight-grained, medium fine-textured, moderately hard, strong and heavy (sp. gr., 0.643 : wt., 641 kg./cu.m.). It exhibits a pronounced Russel effect of acting on photographic emulsions in total darkness. The wood can be seasoned well with care : green conversion

accompanied by removal of the heart has been recommended. Girdling and water- or kiln-seasoning have also been found suitable. Newly felled logs are liable to be bored by the beetle *Xyleborus butamali* Beeson [Pearson & Brown, II, 670-71 ; Nambiyar, Indian For., 1952, 78, 490 ; Limaye, Indian For. Rec., N.S., Timb. Mech., 1954, 1, 49 ; Limaye & Sen, ibid., 1953, 1, 75 ; Mathur & Balwant Singh, Indian For. Bull., N.S., No. 171(7), 1959, 2].

The wood is moderately durable under cover ; graveyard tests indicated an average durability of 7-10 years. The heartwood is very refractory to treatment, side and end penetration of preservatives being practically nil. The timber is easy to saw ; it is liable to wind as it comes off the saw, when cut either for planks or rafters. It works well and takes a good polish. For rotary-cut veneers and plywood, it peels off easily and yields plywood 1-3 mm. thick. The data for the comparative suitability of the timber, expressed as percentages of the same properties of teak, are : weight, 90 ; strength as a beam, 90 ; stiffness as a beam, 105 ; suitability as a post, 95 ; shock-resisting ability, 100 ; retention of shape, 65 ; shear, 85 ; and hardness, 90 (Pearson & Brown, II, 671 ; Purushotham



F.R.I., Dehra Dun. Photo : S. S. Ghosh
FIG. 89—PALAQUIUM ELLIPTICUM—TRANSVERSE SECTION OF WOOD ($\times 10$)

PALAQUIUM

et al., *Indian For.*, 1953, 79, 49; Trotter, 1944, 92; Limaye, loc. cit., Sheet No. 8).

The wood is used for building purposes as planks, door and window frames, flooring, ceiling boards and shingles. It is also used for cheap furniture, veneers, commercial and tea-chest plywood, cabinet making, crates, packing cases, guide skids in mines, jetty piles, masts and spars. It has been found suitable for aircraft quality plywood meeting the requirements of Grades A and B. It has also been recommended for bent-wood furniture. The wood in the green state is reported to have a corrosive action on certain metals, particularly iron and lead [Pearson & Brown, II, 671; *Indian For.*, 1952, 78, 276, 278; IS: 399-1952, 32, 35, 38; Khalil, *Pakist. J. For.*, 1960, 10, 67; Ramamritham & Narasimhan, *Comp. Wood*, 1953-54, 1, 138; Rehman et al., *Indian For.*, 1956, 82, 469; Purushotham, *J. Timb. Dryers' & Pres. Ass. India*, 1959, 5(1), 1].

An inferior kind of gutta-percha, sometimes known as Indian gutta-percha or *pala* gum, may be obtained from the tree. The flow of the milky latex, which is collected by tapping the tree, is quite profuse; the yield from 40 incisions made along the entire length of a trunk was c. 5.6 litres. The trees, however, require a period of rest after frequent incisions. The latex may be coagulated by the addition of alcohol and creosote mixture (20:1), ammonia, lime water or caustic soda. The latex contains (2 samples): water and water solubles, 56.7, 71.3; and gutta, 10.8, 7.3%. Analysis of the coagulum (gutta-percha) obtained from several localities gave the following range of values: gutta, 24.9-33.6%; resins, 60.5-65.7%; and insolubles, 5.9-11.6%. Though highly resinous and of not much commercial value, it is reported to be suitable for use as a coating on rope soled shoes and in the manufacture of ground sheets. It may also be found suitable as waterproofing cement, glue and bird lime. It may be used as a diluent of true gutta-percha to the extent of 10-15% (Cameron, 171; Budhiraja & Beri, *Indian For. Leaflet*, No. 70, 1944, 10, 14; Puran Singh, *Indian For.*, 1913, 39, 371).

The seeds yield an oil, useful for lighting and soap making (Krishnamurti Naidu, 62).

P. obovatum (Griff.) Engl. syn. *Dichopsis obovata* (Griff.) C.B. Clarke

D.E.P., III, 108; Fl. Br. Ind., III, 542.

ASSAM—*Kathulua, daser-changne, wai-to-phang.*

A medium-sized to large tree found in Assam. Bark dark brown, rough; leaves obovate-oblong or elliptic-

obovate; flowers in dense axillary clusters; berries globose, c. 2 cm. across, 1 or 2-seeded.

The tree yields a white gutta-percha of an inferior quality, used for mixing with the superior product from *P. gutta*. The latex from *P. obovatum* contains both gutta and caoutchouc. Analysis of the dried latex coagulum (from Thailand) gave the following values: acetone-soluble fraction, 65.1-75.9%; acetone-insoluble fraction, 24.1-34.9%; caoutchouc, 1.3-4.5%; and gutta, 6.4-21.5%. The wood is dull reddish and hard. It is liable to split in drying, but is reported to be durable under water. It is used for building and boat planking (Burkill, II, 1640-41; Leeper & Schlesinger, *Science*, 1954, 120, 185).

P. polyanthum (Wall.) Baill. syn. *Dichopsis polyantha* (Wall.) Benth. & Hook. f.

D.E.P., III, 108; C.P., 628; Fl. Br. Ind., III, 542.

BENG.—Tali.

GARO HILLS—*Salua*; **KHASI HILLS**—*Dieng-horua*; **CACHAR**—*Bonthai pionbuphang, kurta*; **LUSHAI & KUKI HILLS**—*Kherual*.

A medium-sized tree found in Assam. Bark dark brown with horizontal patches of greenish white; leaves obovate-oblong; flowers in axillary clusters, fragrant; berries obovoid, 3.75 cm. long, velvety brown, 1-seeded. The tree has a slow rate of growth with a mean annual girth increment of 1.45 cm. (Negi & Bhatia, *Indian For. Rec.*, N.S., *Timb. Mech.*, 1958, 1, 171).

The wood is red, moderately interlocked-grained, somewhat coarse-textured, hard, strong and heavy (sp. gr., 0.704; av. wt., 721 kg./cu.m.). It seasons well with care. It is easy to work and finish and is durable under cover. The data for the comparative suitability of the timber, expressed as percentages of the same properties of teak, are: weight, 105; strength as a beam, 95; stiffness as a beam, 100; suitability as a post, 95; shock-resisting ability, 115; retention of shape, 55; shear, 125; and hardness, 120. The wood is used for house construction, door and window shutters, planking, general carpentry work and for making beds, tools and plywood. The wood in the green state is reported to have a corrosive action on certain metals, particularly iron and lead. The sapwood of dead trees is liable to be bored by the larvae of *Dendrotrogus angustipennis* Jordan and of *Eucorynus* sp. and also by the beetles and larvae of *Xyloctonus scolytoides* Eichhoff [Limaye *Indian For. Rec.*, N.S., *Timb. Mech.*, 1954, 1, 49, Sheet No. 8; Limaye & Sen, *ibid.*, 1953, 1, 75; Purushotham,

J. Timb. Dryers' & Pres. Ass. India, 1959, 5(1), 1;
Mathur & Balwant Singh, *Indian For. Bull.*, N.S.,
No. 171 (4), 1959, 30].

The tree yields gutta-percha of an inferior quality, reported to be used for mixing with India rubber. The latex from the plant contains: water and water solubles, 67.9 and gutta, 6.8%; the coagulum contains: gutta, 21.2; resins, 47.9; and insolubles, 30.9%. The flowers are said to be eaten (Budhiraja & Beri, *Indian For. Leaflet.*, No. 70, 1944, 10, 14).

- Pale Catechu — see *Uncaria*
- Palm, Agel — see *Corypha*
- Palm, Arikury — see *Cocos*
- Palm, Assai — see *Euterpe*
- Palm, Assam Fan — see *Livistona*
- Palm, Australian Fan — see *Livistona*
- Palm, Bamboo — see *Raphia*
- Palm, Brazilian Wax — see *Copernicia*
- Palm, Buri — see *Corypha*
- Palm, Cabbage — see *Roystonea*
- Palm, Chinese Fan — see *Livistona*
- Palm, Coconut — see *Cocos*
- Palm, Date — see *Phoenix*
- Palm, Double Coconut — see *Lodoicea*
- Palm, Doum — see *Hyphaene*
- Palm, Dwarf Fan — see *Chamaerops*
- Palm, Fan — see *Corypha*
- Palm, Fishtail — see *Caryota*
- Palm, Gebang — see *Corypha*
- Palm, Gomuti — see *Arenga*
- Palm, Hair — see *Chamaerops*
- Palm Jaggery — see *Borassus*
- Palm, Java Fan — see *Livistona*
- Palm, Kittul — see *Caryota*
- Palm, Lady — see *Rhapis*
- Palm, Mazari — see *Nannorrhops*
- Palm, Nipa — see *Nypa*

- Palm, Oil — see *Elaeis*
- Palm, Palmetto — see *Sabal*
- Palm, Palmyra — see *Borassus*
- Palm, Para — see *Euterpe*
- Palm, Pharaoh's — see *Raphia*
- Palm, Raffia — see *Raphia*
- Palm, Red Latan — see *Latania*
- Palm, Royal — see *Roystonea*
- Palm, Sago — see *Caryota*, *Metroxylon*
- Palm, Sea Coconut — see *Lodoicea*
- Palm, Sugar — see *Arenga*
- Palm, Talipot — see *Corypha*
- Palm, Thatch — see *Thrinax*
- Palm, Toddy — see *Caryota*
- Palm, Wax — see *Ceroxylon*
- Palm, Windmill — see *Trachycarpus*
- Palm, Yatay — see *Cocos*
- Palmarosa Oil — see *Cymbopogon*
- Panama Hat Plant — see *Carludovica*
- Panama Rubber Tree — see *Castilla*

PANAX Linn. (*Araliaceae*) ,
Bailey, 1949, 745.

A small genus of perennial herbs distributed in the north temperate zone in East Asia and North America. Two species, *P. quinquefolium* and *P. schinseng*, supply the drug, American and Chinese Ginseng Root respectively. They do not occur in India but ginseng roots are probably imported; data relating to their import are not available.

P. schinseng Nees syn. *P. ginseng* Mey. (ASIATIC or CHINESE GINSENG) is a perennial herb indigenous to the forests of eastern Asia and cultivated in northern China, Korea and Japan. It was previously the only source of the drug in China but the supply has become so limited that it is now largely met by the import of ginseng root obtained from *P. quinquefolium* of America. *P. quinquefolium* Linn. (AMERICAN GINSENG) is a glabrous herb, 15–45 cm. high, indigenous to eastern U.S.A. and Canada. The root is collected from plants growing wild and also

PANAX

cultivated. The plant can be propagated from seeds. Roots are dug from 5–6 year old plants, washed carefully and dried. Most of the roots gathered in U.S.A. and Canada are exported to China (Hill, 245; Youngken, 607; Bailey, 1947, II, 1339; Sievers, *Fmrs' Bull., U.S. Dep. Agric.*, No. 1999, 1948, 56).

Ginseng root is sub-cylindrical, somewhat spindle-shaped, branched or forked, up to 12 cm. long and 2.5 cm. in thickness, yellowish white (American and Chinese) to yellowish brown (Korean); fracture short. It has slightly aromatic odour and sweetish, aromatic, mucilaginous and slightly bitter taste, somewhat resembling that of liquorice root (Youngken, 607; U.S.D., 1947, 1465).

The active principles present in ginseng have not been clearly characterized. The drug from both the Chinese and American sources was reported to contain a glucoside, panaquilon, besides a saponin (0.75–1%), a bitter substance, resin, tannin, volatile oil (containing a terpene, panacen), sugars, starch and mucilage. Chinese ginseng was reported to contain also vitamins of the B group, colonin (a spermine-like base), a phytosterol, and a steroid hormone with a pronounced estrogenic activity. Later investigations in Russia attributed the activity of Chinese ginseng to the presence of a new active glucoside, panaxoside A ($C_{33}H_{58}O_{12}$, monohydrate, m.p. 176–78°) along with panaxoside B ($C_{33}H_{60}O_{12}$, m.p. 182–85°); both have labile genins, panaxoside A containing 2 glucose units and panaxoside B containing 1 glucose and 1 rhamnose unit. Presence of panacen, β -sitosterol glucoside and daucosterin ($C_{33}H_{60}O_6$, m.p. 305°) was recently confirmed (Schulz, *Acta phytother., Amst.*, 1960, 7, 63; Wehmer, II, 866, 1290; Hoppe, 632; U.S.D., 1947, 1465; *Chem. Abstr.*, 1961, 55, 21490; 1962, 57, 12901; 1937, 31, 6248).

Ginseng is used as a stimulant and aromatic bitter, stomachic and demulcent, and is considered alterative, carminative, tonic, expectorant and antipyretic. It is used as a masticatory. It is reputed to have a sedative effect on the cerebrum and a mildly stimulating action on the vital centres. It is also a gonadotrophic agent containing little toxic substance. Ginseng has a deep influence on metabolism and prevents the development of atherosclerosis. It has the capacity of reducing high blood pressure and raising low blood pressure to the normal level. For this reason, it is administered in cases of hypertension and hypotension [Youngken, 608; Claus, 1961, 136; U.S.D., 1947, 1465; Chopra *et al.*, 522; Kirt. & Basu, II, 1234; Brekhman, *East. Pharm.*, 1961, 4(42), 22].

Panax spp. — see *Nothopanax*, *Polyscias*,
Tieghemopanax

PANCRAZIUM Linn. (*Amaryllidaceae*)

A small genus of bulbous herbs distributed in the temperate and tropical regions of the Old World. Eight species occur in India.

P. zeylanicum Linn.

Fl. Br. Ind., VI, 285; Chittenden, III, 1475. Fig.

A bulbous herb found throughout India and commonly grown in garden borders. Bulbs globose; leaves bifarious, linear-lanceolate; flowers sessile, white, fragrant.

The plant contains an alkaloid, possibly lycorine, which acts as an emetic and causes death by paralysis of the central nervous system. It is used in ear troubles. The roots are irritant in action and employed externally in fevers in Java. In Ceylon, the bulb is said to be medicinal [Burkill, II, 1644; *J. sci. Res. Indonesia*, 1952, 1, suppl., 19].

P. triflorum Roxb., a bulbous herb found in Bihar, Bengal, Orissa, Madras, Deccan, Konkan and Kerala, is used as a substitute and adulterant for *Urginea indica* (Roxb.) Kunth.

Panda — see Sloth Bear and Other Bears

PANDANUS Stickman (*Pandanaceae*)

A large genus of palm-like, evergreen trees or shrubs, widely distributed in the moist tropics of the Old World, from Africa on the west to Pacific Islands in the east. About 36 species have been recorded in India (St. John, *Pacif. Sci.*, 1960, 14, 224).

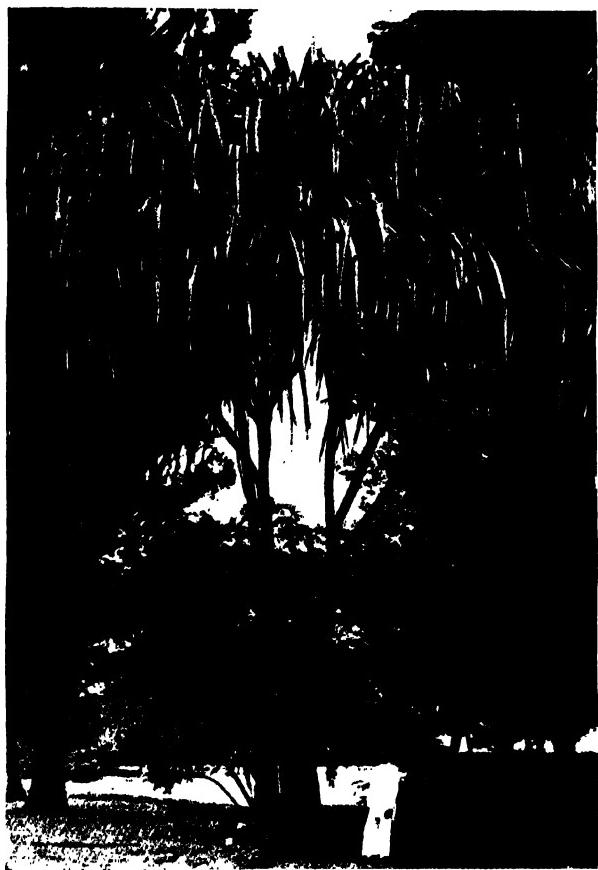
P. andamanensium Kurz

D.E.P., VI(1), 4; Fl. Br. Ind., VI, 485.

HINDI—Keora.

An evergreen tree, frequent in the low moist swampy places in Andaman Islands, especially those subject to flooding during rains. Trunk 9–15 m. high with short sharp prickles and strong roots; leaves 4.5–5.4 m. long and 7.5–10 cm. broad, with slender marginal spines; fruits solitary, large, globose, scarlet when ripe; drupes with a flat or depressed crown, pungent when dry.

The plant yields a fibre which is employed in the Andamans for making various articles of apparel. The fruits are eaten after cooking by the Andamanese. The fibrous parts of the fruit after removal of the softer parts are made into a sort of crude paint brush (Burkill, II, 1645).



F.R.I., Dehra Dun

FIG. 90—PANDANUS FURCATUS

P. foetidus Roxb.

Fl. Br. Ind., VI, 483; Howes, Kew Bull., 1946, 76.

HINDI—Keor-kanta; BENG. Keya-kanta, kotki-kanta.

A prostrate shrub, 0.9–1.5 m. high with glaucous green leaves, 1.2–1.8 m. long, bearing short, sharp marginal spines found in Bengal, Assam and the Khasi hills. The plant is common in the tidal forests and wet places and is frequently planted in Ceylon near fields as a hedge plant. The spathes are yellow and the flowers, both male and female, are foul smelling (Lewis, 365).

P. furcatus Roxb.

D.E.P., VI (1), 4; Fl. Br. Ind., VI, 484; Cooke, II, 813.

BOMBAY—Ran-keura.

A small gregarious tree, with trunk 3–9 m. high and 15 cm. diam., found in Sikkim Himalayas from 600 to 1500 m., in Bengal, Assam, Khasi and Naga

hills, Konkan and Kanara. Leaves dark green, 2.4–4.5 m. long, 7.5–15 cm. wide, with short, stout sharp spines on the margins and midrib; male flowers in compound cylindric spikes, 10–15 cm. long and 1.8–2.9 cm. broad, densely floriferous; spathes golden yellow, inodorous; fruit solitary, orange-red when fully ripe, 15–22.5 cm. long, variable in size.

The plant is reported to form dense impenetrable thickets in marshy places near water courses. It is said to be sometimes cultivated for ornament. The leaves are used in Burma for making mats. The young leaves from the upper part of the stems are used as an antidote for poisoning. The moderately hard wood (wt., 480 kg./cu.m.) is employed in Burma for making floats for fishing nets (Talbot, II, 564; Burkill, II, 1652; Gamble, 740).

P. leram Jones NICOBAR BREADFRUIT

Fl. Br. Ind., VI, 486; Brandis, 659; Macmillan, 97, Fig., p. 98.

A tall slender tree, 12–15 m. in height, found in Andaman and Nicobar Islands; stem repeatedly forked and supported by long, strong aerial roots. It



Industr. Sec., Indian Museum, Calcutta

FIG. 91—PANDANUS LERAM—IN FRUIT

PANDANUS

bears dark green leaves and solitary, large syncarpium, 50–75 cm. long.

The lower portion of the fruit (weight approx., 13–18 kg.) is fleshy and edible. When boiled in water and subjected to pressure, the fruits give out a sort of mealy mass. This is occasionally used with the fleshy interior of the ripe fruit: it has a flavour strongly resembling that of apple marmalade. The fruit is largely used for making flour for bread by the local people [Hedrick, 404; Srinivasan, *Bull. bot. Surv. India*, 1960, 2(1 & 2), 21].

P. odoratissimus Linn. f. syn. *P. tectorius* Soland. ex Parkinson; *P. fascicularis* Lam.; *P. laevis* Kunth; *P. variegatus* Miq.; *P. latifolius* Hassk.; *P. amaryllifolius* Roxb. SCREW-PINE

D.E.P., VI(1), 5; C.P., 777; Fl. Br. Ind., VI, 485.

SANS.—*Ketaki*; HINDI—*Keura, kewda, ketki, gagandhul*; BENG.—*Keya, kedki-keya, keori*; MAR.—*Keora*; GUJ.—*Kewoda*; TEL.—*Mugali* (male), *ketaki, gajangi*; TAMIL.—*Tazhai, thalay*; KAN.—*Tale mara, kyad-agegida*; MAL.—*Kaida, thala*.

A densely branched shrub, rarely erect, found along the coast of India and in Andaman Islands;



Photo : G. P. Gupta

FIG. 92—PANDANUS ODORATISSIMUS—IN FLOWER



FIG. 93—PANDANUS ODORATISSIMUS—SPADIX OF MALE FLOWERS

it is common on the sea shore forming a belt of dense, impenetrable vegetation above the high water mark. Stem up to 6 m. high, supported by aerial roots; leaves glaucous-green, 0.9–1.5 m. long, ensiform, caudate acuminate, coriaceous, with spines on the margins and on the midrib; spadix of male flowers, 25–50 cm. long, with numerous subsessile cylindric spikes, 5–10 cm. long, enclosed in long, white, fragrant, caudate acuminate spathes; spadix of female flowers solitary, 5 cm. in diameter; fruit an oblong or globose syncarpium, 15–25 cm. in diameter, yellow or red; drupes numerous.

This species is the most widespread and has been recorded from Mauritius Islands in the west to Polynesian Islands in the east. It is highly polymorphous and has been described under several specific names. It includes numerous varieties and forms, some of them fixed and selected in various countries for specific uses. An unarmed form, *forma laevis* Warb., is cultivated for the fragrant bracts of the inflorescence, while *forma saniak*, a group of prickly pandans, is preferred for the tough leaves suitable for matting; another form with longitudinal yellow bands on leaves (*forma variegatus*) is grown for ornamental purposes. In Pacific Islands, some of

the forms (e.g. forma *pulposus*) are cultivated for their edible fruits; they are said to be carefully propagated by cuttings. A detailed study of these variants and their systematic position is still lacking [Burkhill, II, 1650; Warburg in *Das Pflanzenreich*, IV(3), 46].

The plants are found growing generally along banks of rivers, canals, fields, ponds, etc.; they are considered to be good soil binder. The male inflorescences are valued for the fragrant smell emitted by the tender white spathes covering the flowers and for the valuable attar obtained from them. Though found scattered over a large number of places in India, the commercial exploitation of male spadices is centred mostly around Kollapalli, Meghna and Agraram in Ganjam district (Orissa), and a few centres in Madras and Uttar Pradesh (Information from B.C. Gulati; Dhingra *et al.*, *Perfum. essent. Oil Rec.*, 1954, 45, 219).

Cultivation—The plant can be propagated by offsets or division of the suckers. For raising scented types, a fertile, well-drained soil is preferable. The tree begins to flower 3 to 4 years after planting. The flowering is chiefly during the rains (July–October). The spadices take a fortnight to mature, depending upon the weather conditions. In India and Burma, the male flowers are valued for their fragrance and used as a hair decoration. They are also used for the extraction of *kewda* attar and *kewda* water, highly prized by Indian perfumers. A fully mature tree bears 30–40 spadices in a year. It is estimated that there are about 300–400 thousand trees in Ganjam district and nearly 10 million spadices are used annually for the production of *kewda* attar, *kewda* water and *kewda* oil (Haines, V, 877; Information from B. C. Gulati).

A leaf blight caused by *Alternaria tenuis* Nees has been recorded. Under high humidity and temperature, the fungus covers large spots which turn black and often cover the entire leaves; perforations appear, leading to premature defoliation and scanty flowering (Kamal, *Curr. Sci.*, 1950, 19, 125).

Kewda attar is prepared by distilling the ripe spadices with water and absorbing the vapours in sandalwood oil or refined liquid paraffin; the latter is used when cheaper grades are required. The spadices are freed of green leaves and are cut into 3–4 pieces before they are distilled; the ratio of spadices to water is kept at 2:1 by volume. Ripe spadices, creamy in colour, give higher yields of perfume and of better quality than immature ones. Several grades

of *kewda* attar are prepared, depending on the quantity of spadices consumed per pound of sandalwood oil (or liquid paraffin), but standards for determining their quality have not been fixed. To obtain *kewda* water, the spadices are simply distilled with water (Dhingra *et al.*, *Perfum. essent. Oil Rec.*, 1951, 42, 114; Information from B.C. Gulati; Menon, 39–40).

Kewda attar is one of the most popular perfumes, extracted and used in India since ancient times. It blends well with almost all types of fancy perfumes and is used for scenting clothes, bouquets, lotions, cosmetics, soaps, hair oils, tobacco and *agarbatti*. *Kewda* attar and water are used for flavouring various foods, sweets, syrups and soft drinks. They are popular in N. India, especially on festive occasions (Sadgopal, *Yearb. Soap, Perfum. Cosm.*, 1959, 14; Menon, 39–40).

Oil of *kewda* is not extracted in India on a commercial scale; the solubility of *kewda* oil in water is so high that it cannot be separated from the distillate by ordinary physical means. Sometimes perfume of the *kewda* spadices is extracted with sesame seeds, by the modified enfleurage process, as used for jasmine and the extracted oil is used as hair oil alone or after admixture with jasmine-perfumed sesame oil. It has also been reported that *kewda* oil based on palmarosa oil is extracted in Orissa. *Kewda* oil has been experimentally prepared by extracting the spadices with a solvent, precipitating the fatty and waxy matters with alcohol and distilling the absolute under reduced pressure. The oil, obtained in a yield of 0.1–0.3%, was light yellow, with a strong characteristic and fascinating odour, reminiscent of lilac, superimposed on hyacinth and tuberose notes. It had the following characteristics: d^{20} , 0.9824–1.0880; n_{D}^{20} , 1.4920–1.5220; $[a]_D$, +0° to +2.0°; acid val. up to 5; ester val., 16.0–45.0; ester val. after acetylation, 54.0–142.0; and sol. in all proportions of 90% alcohol. A different technique was used at H.B. Technological Institute, Kanpur, for the extraction of oil. The spadices were distilled with steam and the vapours collected in a volatile solvent which was later removed by distillation under vacuum. Spadices from Ganjam district gave a yield of 0.03% oil and those from Ghazipur (U.P.) about half this amount. The oil was light yellow in colour, with a fugitive, oriental type odour. It had the following characteristics: sp. gr.²⁰, 0.9320–0.9584; n^{20} , 1.4854–1.4908; $[a]_D$, +1.35° to +2.08°; acid val., 1.4–6.7; ester val., 15.9–40.9; ester val. after acetylation, 80.7; and sol. in equal volumes of 80% alcohol (Sadgopal, loc. cit.);

PANDANUS

Dhingra *et al.*, *Perfum. essent. Oil Rec.*, 1951, **42**, 114; 1954, **45**, 219.

Extraction of the spadices (from Ganjam district) with benzene yields 0.13% of concrete (m.p., 45° ; acid val., 66.8 ; ester val., 97.5) which on treatment with 95% alcohol gives an otto (0.03% on the wt. of spadices) with the following characteristics: sp. gr.²⁰, 0.9067; n^{20} , 1.4363; [α]_D, +2.2°; acid val., 4.4; and ester val., 24.3. The otto has comparatively low specific gravity and refractive index (Dhingra *et al.*, *Perfum. essent. Oil Rec.*, 1954, **45**, 219).

The chief constituent of *kewda* oil is methyl ether of β -phenylethyl alcohol (65–80%) to which is due the characteristic aroma of the spadices. The oil also contains dipentene, *d*-linalool, phenylethyl acetate, citral, phenylethyl alcohol, ester of phthalic acid, fatty acids and stearoptene (Sadgopal, loc. cit.; Dhingra *et al.*, *Perfum. essent. Oil Rec.*, 1954, **45**, 219; Deshpandé, *J. Indian chem. Soc.*, 1938, **15**, 509).

The terminal bud is eaten under the name of cabbage. The tender floral leaves are eaten raw or cooked with various condiments. In the Philippines, the leaves are cooked with rice for imparting the smell of new rice. They are also used to flavour creams and sherbets (Hedrick, 404; Quisumbing, 80).

The pulp contained in the lower part of the drupe is eaten in parts of S. India in times of scarcity; they contain considerable amount of raphides or crystals, that cause irritation in the mouth; however, there are distinct races, some containing so few raphides that they serve as staple food in parts of Polynesia. A race of this species, known in the Marshall Island is said to have a sweet flesh with the flavour of apple. The seeds are also reported edible though their separation from surrounding pulp is laborious (Burkill, II, 1645; Degener, 47).

The leaves are employed for covering huts, for making matting, cordage, hats, baskets and other fancy articles; they are also used for making umbrellas. In Mauritius, the fibre from the leaves were used for making sacks for coffee, sugar and grain. Leaves cut every second year from one plant yield sufficient fibre for two large bags. In Philippines and other Pacific Islands, the leaves are cured either by heating or sun drying, with or without prior soaking in water. Superior quality mats are said to be made from young leaves freshly harvested, rather than from dead leaves gathered from the ground (Burkill, II, 1651; Degener, 47–48).

The leaves are said to be a good paper making material. The roots are fibrous and are used by basket-

makers for binding. They are cut into lengths, beaten out and are very commonly used as brushes for painting and whitewashing. The root fibre may be used as a substitute for bristle in brush making (Burkill, II, 1651).

The leaves are said to be valuable in leprosy, small-pox, scabies and diseases of the heart and brain. The anthers of the male flowers are given in earache, headache and diseases of the blood (Benthall, 430).

The juice obtained from the whole inflorescence from which the spathes have been removed is said to be useful in rheumatic arthritis in animals. The oil and otto are considered stimulant and antispasmodic and are administered for headache and rheumatism. A medicinal oil is said to be prepared from the roots also (*Annu. Rep. Scheme Res. Indigenous Drugs used in Veterinary practice with special reference to their toxicology*, Indian Coun. agric. Res., 1941, 31; Rama Rao, 424).

The roots used in conjunction with the leaves of *Scaevola koenigii* Vahl furnish a black dye. Juice of the root is added in preparing mortar (Rama Rao, 424; Sampson, *Kew Bull. Addl Ser.*, XII, 1936, 128).

P. thwaitsii Mart.

Fl. Madras, 1969–70.

A common undershrub with thin, densely matted stems and with very flexuous male spadix found in rain forests in very moist situations on the Siddapore ghats of N. Kanara, at Bantwala in S. Kanara up to 300 m. and near Ariyankavu in Travancore. It has very fragrant white flowers. The fibre from the leaves is used for nets, brushes, etc., and the pulp of the fruit is sometimes eaten (Talbot, II, 565).

P. utilis Bory

Vaughan & Wiehe, *J. Linn. Soc., Bot.*, 1949–57, **55**, 28.

A stout branching tree, growing up to 15 m. or more, native of Malagasy (Madagascar), grown in Indian gardens as a decorative plant. Leaves glaucous, erect, 75–200 cm. long, 6–10 cm. broad with many very sharp ascending reddish spines on margins and ribs beneath; male spadix 50–80 cm. long; syn-carp solitary, pendulous, long peduncled, 15–20 cm. in diameter; drupes 100–200, compressed, dome shaped, free in upper half.

The leaves are used for making baskets, Manila hats, and other domestic articles. They are also used for thatching. The fruit provides a starchy food, palatable when cooked (Macmillan, 410).

The male spadices are pleasantly odorous and

edible. They are considered to be aphrodisiac (Hocking, 160).

The ends of the stilt roots are often made into rough brushes for whitewashing. Decoctions of these roots are reported to be effective in the treatment of venereal disease.

PANDOREA Spach. (*Bignoniaceae*)

Bailey, 1949, 904; Bor & Raizada, 42-43, Fig. 31 & 32.

A small genus of evergreen twiners distributed from Australia to Malay Archipelago. A few exotics are grown in Indian gardens.

P. jasminoides (Lindl.) K. Schum. syn. *Tecoma jasminoides* Lindl., and *P. pandorana* (Andr.) Van Steenis syn. *Tecoma australis* R. Br. are two climbing shrubs with handsome evergreen foliage and beautiful, large flowers, indigenous to Australia and commonly cultivated in gardens throughout India. They can be propagated by cuttings during the rains, and they flower in the hot season (Bor & Raizada, 43-44; Gopalaswamiengar, 364).

The leaves and stems of *P. pandorana* give positive tests for alkaloids. The plant is suspected of poisoning stock (Webb, *Bull. sci. industr. Res. Org. Aust.*, No. 268, 1952, 28; Webb, *Bull. Coun. sci. industr. Res. Aust.*, No. 232, 1948, 24).

PANGOLINS (Class *Mammalia*, subclass *Eutheria*, order *Pholidota*, family *Manidae*)

Fn. Br. Ind., *Mammalia*, 595-600.

Pangolins or Scaly Ant-eaters are lizard-like placental mammals, characterized by a covering of large, imbricate, horny scales on the upper surface and sides of the body, a small depressed and narrow head pointed in front, and a very small toothless mouth, provided with a long, sticky and extensile

tongue. Eyes and external ears are also very small, the latter even rudimentary. The fore claws are specially adapted for digging and while walking their points are turned upwards and inwards to avoid being damaged as the animal moves with its fore toes doubled under the feet. Pangolins are terrestrial and nocturnal in habit, measuring 76-163 cm. in length. They are powerful burrowers, digging up nests of ants and termites on which they feed. Some species also climb up the trees in search of their prey. When attacked or alarmed, the animal rolls itself into a compact ball, presenting to the enemy an impenetrable armour of horny plates. They do not survive long in captivity and are said to produce 1-3 young in a litter. The flesh of the animal is eaten and its scales are used as a medicine for rheumatism.

Pangolins are confined to Africa and Asia. There are four African and three Indian species. The African pangolins consist of giant and small forms, distinct in their habit of burrowing or climbing; external ears are absent. The Asiatic species possess external ears and are intermediate in size and habit between the two African types. Of the three Asiatic species, two occur in India (Sterndale, 260-63; Prater, 257-59; Encyclopaedia Britannica, XVII, 183; Jerdon, 314-17; Flower & Lydekker, 204-08; Regan, 634-35; Rees, 298-99; Pycraft, 804-05; Ellerman & Morrison-Scott, 213-15; Adams, *Proc. zool. Soc. Lond.*, 1859, 27, 133; Butler, *J. Bombay nat. Hist. Soc.*, 1897-98, 11, 165; Venning, *ibid.*, 1909-10, 19, 254; Trench, *ibid.*, 1915-17, 24, 590; Chatterjee, *ibid.*, 1922-23, 28, 273; Hopwood, *ibid.*, 1928-29, 33, 439; Underwood, *ibid.*, 1944-45, 45, 605; Hutton, *ibid.*, 1948-49, 48, 805).

Indian Pangolin (*Manis crassicaudata* Gray)

SANS.—*Bajra kit*; HINDI—*Bajra kapta, suraj*

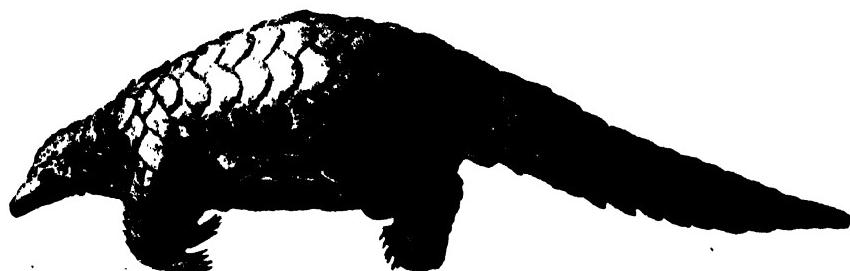


FIG. 94—INDIAN PANGOLIN—*MANIS CRASSICAUDATA*

PANGOLINS

mukhi, silu, sal salu, sakunphor; BENG.—*Kat pohu*; MAR.—*Thiriya, kauli mah, kauli manjra, kassoli manjur*; TEL.—*Alawa*; TAM. & MAL.—*Alangu*.

Indian pangolin is distributed in the plains and lower hill slopes of India, and is characterized by the presence of 11–13 longitudinal rows of yellowish brown scales round the body, and of 14–17 scales in the median row above the tail. Head and body combined measure 60–80 cm., and tail 45–50 cm. Weight of an adult is 9–12 kg.

The burrow dug by the Indian pangolin descends in a slanting direction usually to a depth of 2.4–3.7 m. and ends into a chamber in which the pangolin lives in pairs, sometimes with one or two young; in loose soil the depth of the burrow may be 6 m. or even more. The pangolin can easily climb up the trees in quest of tree ants which it relishes. The animal is easily tamed. Little is known about the breeding habits of the Indian pangolin; in South India, young are usually born between January and March. Its flesh is believed to possess aphrodisiac properties.

Chinese Pangolin (*Manis pentadactyla aurita* Hodgson)

HINDI—*Bajra kit*.

KHASI—*Salak*.

It is found in Sikkim and Naga hills of Assam, and is distinguished from the Indian pangolin by the presence of 15–18, usually 17, longitudinal rows of scales round the body, and of 16–20 scales in the median row above the tail. The scales are smaller and darker than those of the Indian pangolin; head and body combined measure 48–58 cm., and tail 33–38 cm. Weight of an adult is 7–8 kg. Its habits are similar to those of the Indian pangolin. Its flesh is relished by the Chinese.

PANICUM Linn. (Gramineae)

A large genus of annual or perennial grasses distributed mainly in the tropical and warm temperate parts of the world. Two species are grown for their grains used as food in India, while a few others are valued as fodder crops.

P. *antidotale* Retz. BLUE PANIC

D.E.P., VI(1), 7; C.P., 842; Fl. Br. Ind., VII, 52; Bor, *Indian For. Rec.*, N.S., Bot., 1940, 2, 170, Pl. 43.

HINDI—*Guniara*; GUJ.—*Dhusdo, dhusghas*; TAM.—*Nassiam pillu, pinisu pillu*.

PUNJAB—*Gharan, ghamur*; RAJASTHAN—*Bangagli, banwari, gramma*; BOMBAY—*Git, male, girni*.

A coarse perennial grass, with a thick creeping rootstock found in Punjab, Kashmir and upper Gangetic plain and southwards in the Deccan up to Kerala. Culms up to 2.0 m. high; internodes solid, woody; leaves up to 60 cm. x 20 mm.; panicles very diffuse, 15–23 cm. long.

This grass is distributed from India westwards, in Baluchistan, Afghanistan, Arabia, as well as Africa, and eastwards up to Australia. It grows usually in clumps, in bushes and hedges and is grazed by cattle only when quite young; when old it becomes hard and woody and acquires a bitter or saltish taste. The grass is of value at periods when better class of fodder grasses fail; it is drought resistant and winter hardy (Whyte, 354; Whyte *et al.*, 1959, 349).

The indigenous type of this grass has not been reputed so well as fodder grass, as the type introduced from Australia. The latter has shown in trials at Madras to be useful in semi-arid regions, where the annual rainfall does not exceed 63 cm. It has been



I.A.R.I., New Delhi

FIG. 93—PANICUM ANTIDOTALE

found successful in the semi-arid regions of S. India and parts of N. India, where the winters are rather severe. It is susceptible to waterlogging and gives optimum performance on moist, fertile, sandy loam soils (Whyte, 354; Chandrasekaran & Sundararaj, *Madras agric. J.*, 1946, **34**, 21; Dey, *Allahabad Fmr*, 1956, **30**, 206).

The grass produces an abundant quantity of good seeds (c. 300 kg./ha.), comparatively more viable than seeds of other fodder grasses. It is mainly propagated by seeds; propagation by root slips and setts is also possible. Seeds at 4–7 kg. per hectare (11–13 kg. if a good stand is required) are broadcast or drilled in rows at the commencement of the monsoon under rainfed conditions or during spring if irrigation is available. The crop is ready for harvesting in 3 months, but it is advisable to allow 6–8 months for the plants to get a good hold on the soil. It responds quickly to manuring and irrigation. An application of 5–10 cartloads of cattle manure as basic dose supplemented by a top dressing of 225–300 kg. of ammonium sulphate in 3–4 doses is recommended. For best utilization, the grass is cut or grazed while tender. Four to five cuts can be taken in a year, yielding 7–15 tonnes of green fodder in rainfed conditions; it will be possible to take more under irrigation or when the monsoons are favourable. While the average yield under irrigation varies from 15 to 25 tonnes, yields of over 100 tonnes have been recorded under sewage manuring [Whyte, 354–55; *For. Res. India*, 1952–53, pt II, 96; Chandrasekaran & Sundararaj, loc. cit.; Dey, loc. cit.; Gandhi & Sharma, *Indian Fmg*, N.S., 1956–57, **6**(11), 8].

P. antidotale is reported to have been utilized in the U.S.A. for erosion control on flood plains and also as windbreak. As the grass possesses remarkable powers of recovery after each cut, it is particularly suitable for grazing and is said to be palatable to all animals at all stages of growth, except when mature. The quality of its hay has been commended. Analysis of mature green forage (from Karnal) gave (dry basis): crude protein, 7.26; ether extr., 1.19; N-free extr., 43.11; fibre, 40.47; and ash, 7.97%; calcium (CaO), 0.54; phosphorus (P_2O_5), 0.21; iron (Fe_2O_3), 0.048; magnesium (MgO), 0.35; sodium (Na_2O), 0.34; potassium (K_2O), 1.95; aluminium (Al_2O_3), 0.058; sulphur (SO_3), 0.37; and chlorine, 0.62%. The grass has a high content of oxalates (4.9%) (Whyte, 355; Whyte et al., 1959, 349; Lander, *Misc. Bull. Indian Coun. agric. Res.*, No. 16, 1942, 47; *Chem. Abstr.*, 1954, **48**, 14036).

The smoke of the burning plant is said to be used to fumigate wounds and as disinfectant in smallpox. It is said to be employed in throat affections and as antidote for hydrophobia (Kirt. & Basu, IV, 2713).

P. maximum Jacq. syn. *P. jumentorum* Pers. GUINEA GRASS

D.E.P., VI (1), 10; C.P., 843; Fl. Br. Ind., VII, 49; Bor, *Indian For. Rec.*, N.S., Bot., 1940, **2**, 162; Hitchcock, 695, Fig. 1055.

MAR.—*Ginigawat*; GUJ.—*Ginighas*; TAM.—*Gini pullu*; KAN.—*Gini hullu*.

U.P.—*Guinit*.

A tall perennial grass, up to 3 m. high, native to tropical Africa and introduced into India and other tropical countries as a fodder grass. Culms mostly erect, in dense tufts arising from short, stout rhizomes; leaves 30–75 cm. \times 3.5 cm.; panicles 20–50 cm. long, erect or nodding.

This species is exceedingly variable in size, hairiness and, to a lesser extent, in growth habit, though the structure of the spikelet is fairly uniform. It grows well in humid tropical and sub-tropical areas; though drought resistant it will not stand long periods of complete desiccation; severe cold retards its growth. It grows well on a wide variety of well drained soils, except black cracking clays and soils liable to prolonged waterlogging or flooding. Medium loam soils in the warmer parts of India appear to afford optimal conditions. It is tolerant of shade and grows well under trees; it can also be grown to advantage along water channels. *P. maximum* var. *trichoglume* (K. Schum.) Eyles (GREEN PANIC, SLENDER GUINEA GRASS) is said to be able to grow in forest shelter and suppress *Lantana* and to be more tolerant of heavy grazing than common Guinea grass. Several other varieties and strains are known in Africa, Australia and America possessing similar attributes (Whyte, 348–49; Whyte et al., 1959, 350; Dutt & Pugh, 348; Marriott & Winchester, *Qd agric. J.*, 1951, **73**, 19).

The plant is propagated by root slips and setts, though it can also be propagated by seeds. The earheads ripen very unevenly and seeds are shed early, making their collection difficult (yield of seeds, c. 62 kg./ha.); the viability of the seeds also is low (2–10%). *P. maximum* is reported to be a facultative apomict with 1–5% of cross-fertilization (Dutt & Pugh, 348; Whyte, 348; *For. Res. India*, 1952–53, pt II, 96; Bogdan, *E. Afr. agric. J.*, 1958–59, **24**, 206).

Guinea grass can be planted from mid-February

PANICUM

onwards under irrigation, but under rainfed conditions, it is done immediately after the outbreak of monsoon. Since the grass forms large clumps, a spacing of 90 cm. x 90 cm. or 90 cm. x 60 cm. is desirable. The crop is reported to do very well under irrigation, particularly with sewage water. Application of 10–40 cartloads of farmyard manure as a basal dressing and top dressing with sufficient quantities of compost and sulphate of ammonia after every 2–4 cuts are considered beneficial. High yields (c. 225 tonnes/ha.) have been obtained in experimental plots manured with sodium nitrate and ground *mahua* cake in the ratio of 2:1 to supply 175 kg. N per hectare (Dutt & Pugh, 348; Whyte, 349; Whyte *et al.*, 1959, 350; *Leafl. Dep. Agric. Bombay*, No. 9, 1937; Dey, *Alahabad Fmr.*, 1956, 30, 206).

The first cut is obtained about 2½ months after planting and then at intervals of 6–8 weeks, depending upon the soil fertility, irrigation and manuring. The crop is cut while it is green and tender, just at the time of flowering, before the stems get coarse and tough. It is stated that the more often the crop is cut the finer and better will be the fodder. Average yields vary from 38 to 63 tonnes per hectare per annum, but with application of fertilizers or manuring with night soil and sewage water, yields up to 250 tonnes per hectare have been recorded (Whyte, 349; Dutt & Pugh, 348; Dey, loc. cit.; Narayan Rao, *Agric. J. India*, 1910, 5, 362).

The crop can give a continuous supply of green fodder for several years. But generally, after a few years, the clumps become big, yields fall and interculture becomes difficult. Replanting is, therefore, recommended after every 3–5 years (Lander, 155; Whyte, 349; Dutt & Pugh, 348; Narayan Rao, loc. cit.).

Guinea grass is used mainly as green fodder, but it also makes an excellent silage and hay. It is relished by all kinds of livestock. It is more nutritious than Napier grass (*Pennisetum purpureum*) and compares favourably with *jowar* and maize fodder. Chemical composition and nutritive value of the green feed, hay and silage are given in Table 1 (Lander, 155; Whyte *et al.*, 1959, 350; Ramiah, *Bull. Dep. Agric. Madras*, No. 33, 1941, 15).

The grass is rich in carotene (24.2–39.2 mg./100 g.) and contains vitamin B₁, vitamin C and tocopherol (23.0–34.6 mg./100 g.). The mineral constituents reported are (av. values, dry basis): total ash, 13.87; ash sol. in HCl, 7.1; calcium (CaO), 0.71; phosphorus (P₂O₅), 0.56; potassium (K₂O), 2.92; sodium (Na₂O), 0.41; and magnesium (MgO), 0.45%. The grass also contains: iron (as Fe₂O₃), 52.6 mg.; iodine, 12–31 µg.; chlorine, 560 mg.; and sulphur, 180 mg./100 g.; total oxalates (as oxalic acid), 1.5% on dry basis. Phytic acid phosphorus accounts for 30% of the total phosphorus (Ramanujan & Anantakrishnan, *Indian J. Dairy Sci.*, 1958, 11, 101; Teik, *Sci. Ser. Dep. Agric., Malaya*, No. 24, 1951, 83; Sen, *Bull. Indian Coun. agric. Res.*, No. 25, 1952, 12; Murty, *Indian J. Dairy Sci.*, 1957, 10, 67; Iodine Content of Foods, 107; Momin, *Pakist. J. Sci.*, 1950, 2, 42; *Chem. Abstr.*, 1954, 48, 14036; Gowda *et al.*, *Indian J. med. Res.*, 1955, 43, 603).

In S. Africa, *P. maximum* has been suspected of causing a sheep disease called 'dikoor' under certain climatic conditions during the earliest stages of growth of the plant and in certain stages of growth of the smut fungus upon the plant. The plant is said to cause fatal colic if given in too large a quantity or when wet. Traces of hydrocyanic acid are said to be found in stems and leaves and rather more in roots

TABLE 1—COMPOSITION AND NUTRITIVE VALUE OF GUINEA GRASS*

	Crude protein	Digestible protein	Fat	N-free ext.	Crude fibre	Ash	Total digestible nutrients	Nutritive ratio
	%	%		%		%	%	1:
<i>Green forage</i>								
Cut at young stage	7.9	5.8	1.2	37.0	38.4	15.5	65.1	10.2
Cut at prime stage	4.8	..	0.7	40.1	42.1	12.32	..	..
<i>Hay</i>								
Cut before flowering	7.6	4.1	1.2	37.1	38.1	16.0	47.3	10.6
Cut in flower	4.8	2.1	1.1	39.7	42.1	12.3	46.7	21.3
<i>Silage</i>	5.2	..	1.5	44.6	38.7	9.9	..	..

* Sen, *Bull. Indian Coun. agric. Res.*, No. 25, 1952, 12, 16, 18, 26, 27.

(Steyn, 150; Chopra, Nayar & Chopra, 185; Quisumbing, 1024; Burkhill, II, 1656).

Ingestion of juice from Guinea grass is reported to stimulate the movements of isolated intestines of goats and other ruminants; addition of a small quantity of the grass to lucerne feed counteracts the inhibitory effects of the latter on intestines and may, therefore, prove useful in preventing tympanitis in cattle (Sadhu *et al.*, *Proc. Indian Sci. Congr.*, 1956, pt III, 363; Chowdhury *et al.*, *ibid.*, 1956, pt III, 363).

P. miliaceum Linn. COMMON MILLET, PROSO MILLET, HOG MILLET

D.E.P., VI(1), 12; C.P., 843; Fl. Br. Ind., VII, 44.

HINDI.—*Chena, cheen*; BENG.—*Cheena*; MAR.—*Varo, vari*; GUJ.—*Chino, vari*; TEL.—*Varagalu, variga*; TAM.—*Panivaragu, kadukanni*; KAN.—*Baragu*.

A shallow rooted, erect annual, 30-100 cm. high, with a tendency to tiller freely; leaves 15-30 cm. x 6-20 mm.; panicles slender, up to 45 cm. long, either open or compact; spikelets rather large, 4-5 mm. long, glabrous, green or brownish green; kernel or grain white, broadly ovate, firmly surrounded by the glume and palea, often coloured, the ripe grain shedding easily.

This species is not known in a wild state. A closely allied species, *P. spontaneum* Lyssov ex Zukovskij, occurs often as a weed along with this millet in Afghanistan, Kazakhstan and Mongolia and is considered as a derivative of *P. miliaceum* rather than *vice versa*. Based on a study of over 5,000 specimens of this millet, it has been proposed that two main groups can be recognized, viz. *effusum* and *contractum*, each comprising a large number of ecotypes (Mansfeld, Zuchter, 1952, 22, 304; Zukovskij, 10; *Plant Breed. Abstr.*, 1954, 24, 569).

The cultivation of this millet is said to be as ancient as that of wheat itself. It was considered in earlier works to be of Egypto-Arabian origin, but most of the recent authorities agree in ascribing to it a central or eastern Asiatic origin, since the diversity in all characters increases towards Mongolia, China and Eastern Asia. Besides India, the principal cultivating areas for this crop are Mongolia, Manchuria, Japan, Southern and Central Russia, Central Europe, countries of the Middle East and U.S.A. (Vavilov, 21; Mansfeld, loc. cit.; Werth, *Curr. Sci.*, 1937-38, 6, 355; Ames, 102; Mann, *World Crops*, 1950, 2, 97).

In India, the chief producing States are Andhra Pradesh, Maharashtra, Mysore and Madras; it is also

grown to a small extent in Bihar, Madhya Pradesh, Uttar Pradesh and Punjab. No separate data are available regarding its area and production in different States. The data for *P. miliaceum* are grouped together under Small Millets or Minor Millets along with *P. miliare* (Little Millet), *Echinochloa crus-galli*, *E. frumentaceum*, *Paspalum scrobiculatum* Linn. and *Setaria italica* Beauv., and their area and production are estimated combined in Government records. Further, the figures are collected in the various areas in India on the basis of their vernacular names, the same or similar vernacular names being applied sometimes to different species in different areas. Hence an accurate picture of the area and production pertaining to each species of the small millets in India is not available. Table 2 gives the area and production of small millets as a whole in the different States of India.

The chief districts of cultivation of small millets in different States in India are: Kurnool, Anantapur, Guntur, Mahbubnagar, Nellore and Cuddapah in



FIG. 96—PANICUM MILIACEUM—FLOWERING BRANCH

TABLE 2—AREA AND PRODUCTION OF SMALL MILLETS IN INDIA

	Area (thousand acres)					Production (thousand tons)				
	1959–60	1960–61	1961–62	1962–63	1963–64	1959–60	1960–61	1961–62	1962–63	1963–64
Madhya Pradesh	3,643	3,570	3,405	3,434	3,433	341	336	301	251	342
Andhra Pradesh	2,596	2,574	2,619	2,588	2,549	422	403	399	414	432
Uttar Pradesh	1,591	1,532	1,486	1,437	1,383	263	250	247	230	301
Madras	1,259	1,258	1,332	1,331	1,310	403	413	417	417	411
Mysore	1,062	1,035	1,004	932	927	124	120	141	123	127
Bihar	751	699	591	575	534	138	106	88	102	97
Gujarat	533	457	414	354	333	166	141	170	121	116
Maharashtra	475	450	453	508	497	88	82	83	79	80
Rajasthan	168	194	208	178	171	30	35	37	26	26
Orissa	114	115	97	88	88	14	18	20	31	31
Himachal Pradesh	63	62	61	61	61	11	10	10	10	10
Jammu & Kashmir	62	58	57	61	61	14	14	15	16	16
Punjab	50	47	12	10	7	5	5	2	2	1
West Bengal	25	22	15	15	15	5	5	3	3	3
Kerala	15	14	17	17	17	3	3	3	3	3
Assam	13	14	14	17	16	2	3	3	3	3
All India Total	12,420	12,101	11,785	11,596	11,402	2,029	1,944	1,939	1,812	1,999
	(5,026)	(4,897)	(4,769)	(4,692)	(4,614)	(2,062)	(1,980)	(1,970)	(1,841)	(2,031)

Figures in brackets give total area in thousand hectares and total production in thousand metric tonnes.

Andhra Pradesh, Ranchi and Palamu in Bihar, Kaira and Panch Mahals in Gujarat, Durg, Mandla, Bastar, Shahdol and Sidhi in Madhya Pradesh, Ratnagiri in Maharashtra, Salem, Tiruchirappalli, Ramanathapuram, Madurai, S. Arcot and N. Arcot in Madras, Chitradurga, Raichur, Tumkur and Bellary in Mysore, Sirohi and Banswara in Rajasthan, Basti, Gorakhpur, Deoria, Gonda and Mirzapur in Uttar Pradesh and Mahasu in Himachal Pradesh.

A large number of types of the common millet are recognized, differing in such characters as plant colouration, hairiness and seed colour. They are—green or, as it is called, an unpigmented type and two types with purple pigmentation, the purple and the light purple ; a hairless type and three hairy types differing in the degree of hairiness ; and seven distinct grain colour types, all of which are represented in varieties obtained from Russia. Only two types, the dark olive grey and buff yellow are reported from Madras. Some high yielding selections have been

reported to be made in Madras and Mysore. Russian varieties are said to be much earlier than those from China or India, this character being a great advantage with a crop whose value lies largely in its early ripening [Ayyangar & Rao, *Madras agric. J.*, 1938, 26, 195 ; *Mem. Dep. Agric. Madras*, No. 36, 1954, 176 ; Rao, *Indian Fmg. N.S.*, 1954–55, 4(4), 27 ; Mann, *Emp. J. exp. Agric.*, 1946, 14, 208].

Climate & Soil—The common millet grows further north than any other millet, the northern limit of cultivation of this as well as other *Panicum* millets being a June isotherm of 63°F. and a July isotherm of 68°F. These millets are specially adapted to conditions, where there is a hot summer, whether in tropical or higher latitudes, where the rainy season is short and the soil thin and poor. Among grain crops, the common millet has the lowest water requirement ; it grows well on any kind of soil except coarse sand. It is well adapted for plateau lands and high elevations and is cultivated in the Himalayan

region (Almora) up to a height of 2,700 m. It is generally grown on the poorer types of soils and is raised as a late monsoon crop. On account of its short duration and quick growth, this crop is valued for areas where other crops would not succeed (Anderson & Martin, *Econ. Bot.*, 1949, **3**, 265 ; Mann, loc. cit. ; Yegna Narayan Aiyer, 103).

The crop responds to good cultivation. It is sown as a cold weather crop in October–November in Andhra Pradesh and Madras and is practically the last crop to be sown in the year. In Bombay, where the crop is grown by transplanting seedlings, it is transplanted early in July. In Punjab it is sown in March. Seed at 8–11 kg. per hectare is either broadcast or sown through seed drills in rows about 22 cm. apart and covered with a brush harrow. The crop is mostly rainfed, but in parts of Madras it is grown under well irrigation (Yegna Narayan Aiyer, 103 ; *Mem. Dep. Agric. Madras*, No. 36, 1954, 175 ; Roberts & Kartar Singh, 283 ; Solomon, *Bull. Dep. Agric. Bombay*, No. 186, 1951, 46).

The crop is not subject to any serious diseases or pests. A smut affecting the earhead has been reported, but it can be controlled by treatment with copper sulphate (Yegna Narayan Aiyer, 103).

The crop is ready for harvest in 70–90 days. The plants are pulled up and as the grains shed badly, it is not stacked but threshed soon after harvest. The yield varies from 450–560 kg. in dry lands to 1,125–1,700 kg. per hectare under irrigation ; in the rich black soils of Guntur, yields up to 2,270 kg. per hectare have been recorded in years of favourable

rainfall. Yield of straw is a little more than that of the grain. It is fed to cattle, though in N. India it is considered somewhat heating and is more often used as bedding for cattle. In Punjab, the crop is reported to be cut as green fodder before it ripens. In Madras and Mysore, the dry straw is regarded as equal in value to rice straw (Mudaliar, 182–83).

Uses & Composition—The husked grain (70% of the whole grain) is considered nutritious and is eaten whole, boiled and cooked like rice ; sometimes it is ground into flour for making *chapati*. It is also parched into *marha* or *mard*. It is used also for making porridge and bread ; it is fermented into a kind of beverage in Ethiopia. In U.S.A., it is particularly valued as a hog feed (protein, 11.9 ; dig. protein, 8.4 ; and total dig. nutrients, 76.9% ; nutritive ratio, 8.2) and used as a substitute for corn or sorghum in areas where neither would mature (Yegna Narayan Aiyer, 104 ; Mudaliar, 183 ; Roberts & Kartar Singh, 283 ; Solomon, loc. cit. ; Hill, 330 ; *Chem. Abstr.*, 1931, **25**, 4353 ; Morrison, 459, 1959).

Analysis of the husked grains gave : moisture, 11.9 ; protein, 12.5 ; fat (ether extr.), 1.1 ; carbohydrates, 68.9 ; fibre, 2.2 ; and mineral matter, 3.4% ; calcium, 10 ; phosphorus, 330 ; and iron, 5.7 mg./100 g. The grains contain the following vitamins : thiamine, 0.78 ; riboflavin, 0.10 ; and niacin, 1.0 mg./100 g. ; they also contain 852 mg./100 g. of choline (as choline chloride, on dry basis). Carotene and ascorbic acid are absent (*IIIth Bull.*, No. 23, 1951, 28 ; Chatfield, *FAO nutr. Stud.*, No. 11, 1954, 11 ; Ahmad et al., *Indian J. med. Res.*, 1953, **41**, 441).

The grains contain 10–18% of proteins which include prolamin, glutelin and smaller amounts of albumin and globulin ; nuclein and γ -globulin have been isolated. The essential amino acids present in the total protein are (g./16 g. N) : arginine, 2.89 ; histidine, 1.90 ; isoleucine, 4.04 ; leucine, 10.13 ; lysine, 2.06 ; methionine, 2.47 ; phenylalanine, 4.86 ; threonine, 3.63 ; tryptophan, 1.38 ; and valine, 5.12. Common millet protein has a biological value of 56% and a digestibility co-efficient of 91%, at 10% level of protein intake. Feeding trials with rats indicate that it has a lower supplementary value than the proteins of wheat or rice (Winton & Winton, I, 124 ; *Chem. Abstr.*, 1944, **38**, 171 ; 1952, **46**, 6204 ; Lyman et al., *J. agric. Fd Chem.*, 1956, **4**, 1008 ; Kuppuswamy et al., 13 ; Kundaji & Rao, *Curr. Sci.*, 1954, **23**, 93).

The grains contain starch as the chief carbohydrate, with minor amounts of sugars and dextrans.

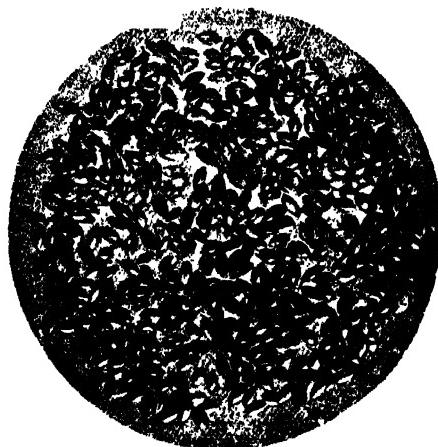


FIG. 97—PANICUM MILIACEUM—GRAINS

The starch can be recovered by steeping the grains in water, followed by milling, alkali treatment and tabling (yield, 52%). It is similar to corn starch in appearance and other properties; it consists of 31.2% of amylose and 68.8% of amylopectin and has a gelatinization temperature of 76°. It is reported to be suitable for use as a sizing agent in the textile industry (Winton & Winton, I, 125; Patel, *Curr. Sci.*, 1943, **12**, 325; Patel *et al.*, *Sci. & Cult.*, 1958-59, **24**, 291).

Common millet yields (up to 7%) a yellow, semi-drying oil with the following characteristics: d^{15} , 0.9383; n_{D}^{20} , 1.4577; acid val., 12.8; sap. val., 191.5; iod. val. (Wij's), 129; thiocyanogen val., 80.0; hydroxyl val., 17.1; R.M. val., 1.76; and unsapon. matter, 3.3%. The fatty acid composition of the oil is: volatile, 4.3; saturated, 11.5; oleic, 25.8; linoleic, 50.6; and linolenic acid, 7.8%. The unsaponifiable matter is reported to contain a phytosterol (m.p. 134°), a keto-alcohol named prosol ($C_{24}H_{36}O_2$, m.p. 279°), and miliacin ($C_{12}H_{18}O$), a crystalline substance related to terpenes (Mensier, 420; Eckey, 287; Wehmer, I, 74; *Chem. Abstr.*, 1935, **29**, 627).

Analysis of the ash from the grains gave the following values: potassium (K_2O), 11.2; sodium (Na_2O), 1.4; calcium (CaO), 0.7; magnesium (MgO), 9.5; phosphorus (P_2O_5), 22.0; sulphur (SO_3), 0.3; chlorine, 0.3; and others (mostly silica), 54.6%. Trace elements reported are manganese, copper and zinc. The grains contain also calcium magnesium inositol phosphate (Winton & Winton, I, 126; *Chem. Abstr.*, 1932, **26**, 2767).

The green plant serves as an excellent fodder for cattle and horses. Analyses of green forage and hay gave the following values: *green feed*—moisture, 75.3; protein, 2.0; fat, 0.6; N-free extr., 12.9; fibre, 7.4; and mineral matter, 1.8%; dig. protein, 1.2%; total dig. nutrients, 15.6%; and nutritive ratio, 12.0; *hay*—moisture, 9.7; protein, 9.3; fat, 2.2; N-free extr., 47.6; fibre, 23.9; and mineral matter, 7.3%; dig. protein, 5.6%; total dig. nutrients, 50.7%; and nutritive ratio, 8.1 (Blatter & McCann, 160; Morrison, 1028, 1010).

The seedlings contain an alkaloid, hordenine (β -*p*-hydroxyphenethyl dimethylamine, $C_{10}H_{15}ON$, m.p. 117-18°). The plant contains a saponin (Manske & Holmes, III, 320; *Chem. Abstr.*, 1952, **46**, 10548).

P. repens Linn. TORPEDO GRASS

D.E.P., V, 15; Fl. Br. Ind., VII, 49; Hitchcock, 697, Fig. 1058.

BENG.—*Bamdu*; TEL.—*Ladda-gaddi*; TAM.—*Thineipillu*, *injipillu*; KAN.—*Sonti-hullu*; MAL.—*Inchi pillu*; ORIYA—*Panidal*, *reda*.

A perennial grass with a robust elongated creeping rootstock distributed throughout India. Culms erect, 70-150 cm. high; leaves sparsely pilose or glabrous; panicles open, 7-12 cm. long; spikelets 2-2.5 mm. long, ovate.

This grass grows commonly in aquatic and semi-aquatic conditions, in backwaters as well as in dry situations. It is said to withstand flooding as well as drought, the rhizomes remaining alive over long dry periods. It is reported to be a good grass for turfs and lawns and very suitable for soil conservation work. It is palatable, resistant to grazing and trampling, but because of its vigorous and aggressive growth it is, however, liable to become a pernicious weed. However, possibilities are there of growing this grass in permanent pastures in warm humid regions or under irrigation (Macmillan, 69; Ranga Achariay, 99; Whyte *et al.*, 1959, 352; Bor, 1960, 330; Mudaliar & Rao, 435; Gandhi, *Indian J. agric. Sci.*, 1957, **27**, 131).

The grass is fed to cattle, both green and as hay. It has a high nutritive value and is relished by animals. Analysis of the green forage gave the following values (dry basis): crude protein, 8.49; true protein, 7.68; ether extr., 3.16; N-free extr., 48.14; crude fibre, 27.44; and ash, 12.76%; calcium (CaO), 0.67; phosphorus (P_2O_5), 0.73; and silica, 7.9%. It contains also magnesium (0.53%), cobalt (0.05-0.36 p.p.m.) and copper (5.9-10.1 p.p.m.); it is rich in vitamins A and C. Analysis of a sample of hay (in bloom) gave the following values: moisture, 11.45; crude protein, 8.02; fat, 1.52; N-free extr., 52.33; fibre, 21.59; and ash, 5.09%; dig. protein, 4.37%; total dig. nutrients, 55.14%; and nutritive ratio, 11.6. The roots and seeds are reported to be slightly cyanogenic. In Java, the rhizome is reported to be administered in abnormal menstruation (Teik, *Sic. Ser., Dep. Agric., Malaya*, No. 24, 1951, 21, 84; Nath & Das, *Indian J. vet. Sci.*, 1953, **23**, 185; Gowda, *Mysore agric. J.*, 1956, **31**, 241; Datta & Datta Biswas, *Indian J. agric. Sci.*, 1951, **21**, 93; *Chem. Abstr.*, 1945, **39**, 2356; Quisumbing, 1024; Burkill, II, 1651).

P. sumatrense Roth ex Roem. et Schult. syn.

P. miliare Lam. LITTLE MILLET

D.E.P., VI(1), 13; C.P., 845; Fl. Br. Ind., VII, 46; Bor, 1960, 701.

HINDI—*Shavan, kungu, kutki*; BENG.—*Gundli, gondula*; MAR.—*Sava*; GUJ.—*Gadro*; TEL.—*Samalu*; TAM.—*Samai*; KAN. *Shame, save*; MAL.—*Shama*; ORIYA—*Suniva*.

An annual tufted grass with rather slender culms, 30–90 cm. high, and usually leafy up to the panicle; leaves soft, narrow and rather very long for the size of the plant, up to 60 cm. long and 2.5 cm. broad; panicle oblong, 15–40 cm. long with numerous erect, hairy branches, eventually nodding; spikelets 3–4.5 mm. long, glabrous, flattened; caryopsis glabrous, striated, brown.

P. sumatrense is said to be found wild in northern India, up to moderate elevations in Himalayas, in Burma, South-East Asia and Malaysia. It is supposed to have originated in India or South-East Asia from *P. psilopodium* Trin. which is also found wild all over the area and from which it is not easily distinguishable. Several types are said to exist under cultivation in Bihar, Madras, Mysore and Maharashtra exhibiting differences in such characters as grain

colour, plant pigmentation, shape of the panicle, duration of crop in field and ability to flourish in waterlogged soils. Samples from tracts in Vishakhapatnam district (Andhra Pradesh) were found to be much taller, stouter and later maturing (120–140 days) than from Madras; they were less profuse in tillering than those of the southern types but carried good sized earheads. In *P. sumatrense* self-pollination is the rule. High yielding selections of this millet are reported to have been made in Madras and Mysore [Bor, 1960, 329; Ayyangar & Wariar, *Madras agric. J.*, 1941, 29, 461; Yegna Narayan Aiyer, 100; Mudaliar, 180; *Mem. Dep. Agric. Madras*, No. 36, 1954, 177; Rao, *Indian Fmg. N.S.*, 1954–55, 4(4), 27].

This minor millet is grown throughout India and up to an elevation of 2,100 m. in the Nilgiris; it is not an important crop outside India. In India, it is cultivated chiefly in Madras, Mysore and Andhra Pradesh and to a small extent in Bihar (Chota Nagpur), Maharashtra and Madhya Pradesh. The chief areas of cultivation are: Salem, Coimbatore, Madurai and Tirunelveli districts in Madras; Anantapur, Srikakulam, Vishakhapatnam and Chittoor districts in Andhra Pradesh; and dry eastern districts of Mysore (Mudaliar, 180; Yegna Narayan Aiyer, 99).

Little millet is able to thrive in those soils which otherwise yield little or nothing and mature a crop, though small, even in famine years. It is therefore grown generally on poor, light rainfed soils. The land is ploughed 2 or 3 times and the seed is sown broadcast at 12 kg. per hectare, if sown pure. It is sown during the main rainy season (July to October) or even in summer when adequate rains are received. Usually little or no after cultivation is given. Experimental studies have shown that grain yield can be increased by 72% if the crop is transplanted; line sowing along with application of 9 kg. N as ammonium sulphate and 9 kg. P as superphosphate gives maximum response. Little millet may be raised as a pure crop or as a subsidiary crop mixed with other millets like *cumbu, varagu* and *ragi* or pulses like horse gram, or with oilseeds like gingelly, castor and mustard. The crop is reported to be subject to a rust, *Uromyces linearis* Berk. & Br. The crop matures in 2½ to 5 months depending upon the type cultivated. The yield of grain ranges from 225 to 560 kg. per hectare while in good seasons it may go up to 900 kg. and the yield of straw from 800 to 1,100 kg. (Ayyangar & Wariar, loc. cit.; Mudaliar, 179; Yegna



FIG. 98—PANICUM SUMATRENSE—FLOWERING BRANCH

PANICUM

Narayan Aiyer, 99; *Mem. Dep. Agric. Madras*, No. 36, 1954, 177; Naidu & Rao, *Andhra agric. J.*, 1959, 6, 76; Nezamuddin & Rahman, *Sci. & Cult.*, 1959-60, 25, 487).

Little millet is considered to have great potentialities as a quick growing fodder. It is reported to have yielded 21,300 kg. of fodder under irrigation in two cuttings within 138 days and 5,900 kg. of green fodder in 55 days. The straw is thin and soft and cattle consume it readily, but it is considered inferior to that of paddy and ragi (*Mem. Dep. Agric. Madras*, No. 36, 1954, 589; Mudaliar, 181).

The husk forms about 20% of the weight of the grain. The husked grain is white, grey or olive brown in colour and is said to be not tasty. It is cooked like rice and eaten; in parts of Madras the grain is processed in a way similar to the parboiling of paddy. It is also made into flour, used for making puddings or cakes (Mudaliar, 181; Kadkol *et al.*, *Bull. cent. Fd technol. Res. Inst., Mysore*, 1953-54, 3, 247).

Analysis of the whole and husked grains of little millet gave the following values: *whole grain*—moisture, 11.0; protein, 7.2; fat (ether extr.), 4.9; carbohydrates, 63.8; fibre, 9.6; and mineral matter, 3.5%; calcium, 24.0; phosphorus, 320.0; iron, 7.0; and thiamine, 0.34 mg./100 g.; *husked grain*—moisture, 11.0; protein, 7.1; fat, 2.1; carbohydrates, 77.4; fibre, 0.7; and mineral matter, 1.7%; calcium, 19.0; phosphorus, 159.0; iron, 2.6; and thiamine, 0.30 mg./100 g. The grain contains traces of carotene and iodine (38 µg./kg.). The grain starch consists of 32.1% of amylose and 67.9% of amylopectin (Kadkol *et al.*, loc. cit.; *Hlth Bull.*, No. 23, 1951, 28; Iodine Content of Foods, 62; Patel *et al.*, *Sci. & Cult.*, 1958-59, 24, 291).

The essential amino acids present in the proteins of little millet are as follows (g./16 g. N): arginine, 4.66; histidine, 1.87; isoleucine, 6.66; leucine, 10.86; lysine, 1.83; methionine, 2.27; phenylalanine, 4.76; threonine, 3.40; tryptophan, 0.56; and valine, 6.06. The proteins are deficient in lysine and have a biological value of 55%. Feeding experiments with rats have shown that diets based on little millet have lower growth promoting value than diets based on wheat (Ramachandran & Phansalkar, *Indian J., med. Res.*, 1956, 44, 501; Kadkol *et al.*, loc. cit.).

Fresh leaves of the plant contain 18.50 mg./100 g. of carotene [Acharya & Malpoorwala, *J. Univ. Bombay, N.S.*, 1952-53, 21A(32), 47].

Some of the other species of *Panicum* occurring in India and reported to be of some value for food or fodder are:

P. atrosanguineum Hochst. ex A. Rich. syn. *P. hydaspicum* Edgew. is a small annual grass found in Punjab, upper Gangetic plain, and southwards in Madhya Pradesh. It is said to furnish an excellent fodder for cattle. The seeds are said to be collected in southern Punjab by the poor people for food (Bor, 1960, 322; Stewart, 258).

P. auritum Presl ex Nees, a tall perennial grass with erect, soft and stout culms, is found in Assam, Bengal and Bihar and along the western ghats to Kerala. It is often found in forest clearings and forest margins. It is considered to be a good fodder grass in Malaya (Bor, 1960, 324; Burkhill, II, 1655).

P. austroasiaticum Ohwi syn. *P. humile* Nees ex Steud. is a small tufted annual grass with a much branched and often purplish stem found from Assam to Uttar Pradesh in N. India and extending southwards to Orissa and Madras. It is fairly common on cultivated grounds and paddy fields and is reckoned as a good fodder grass (Bor, *Indian For. Rec., N.S., Bot.*, 1940, 2, 165; Burkhill, II, 1655).

P. brevifolium Linn. syn. *P. ovalifolium* Poir. is a grass with slender, sparingly branched decumbent culms at the nodes. It is found in moist shady situations, particularly in forest clearings and has been recorded from Assam, Bengal, Orissa and Madras. It is considered a good fodder grass in Malaya (Bor, 1960, 325; Burkhill, II, 1655).

P. hippocthrix K. Schum. syn. *P. obscurans* (Woodrow) Stapf; *Isachne obscurans* Woodrow (BOMBAY-Tansawa) is an annual grass found in Deccan. The grains are said to be collected and cooked like rice (Cooke, II, 936; Bor, 1960, 326).

P. incomatum Trin. syn. *P. sarmentosum* Fl. Br. Ind., non Roxb. is a tall sprawling perennial grass, with stems sometimes 15 m. long. It is found in the hills and plains of North Bengal and Assam and is distributed in Burma and Malaya, where it is said to be eaten by cattle and is considered to be a good fodder. The roots are regarded as aphrodisiac and chewed with betel nut (Bor, 1960, 326; Burkhill, II, 1657).

P. paludosum Roxb. non Nees syn. *P. proliferum* auct. non Lam. (BENG.—*Borati*; TEL.—*Soda*) is a perennial grass found in the marshes and still waters in almost all parts of India. It has a stout spongy stem, 70-100 cm. long, rooting at the nodes. It is reported to provide a favourite fodder for elephants

and buffaloes. The grain is said to be made into cakes by hill tribes (Bor, 1960, 329; Bor, *Indian For. Rec.*, N.S., Bot., 1940, 2, 167; Burkill, II, 1657).

P. psilopodium Trin. var. *psilopodium* and var. *coloratum* Hook. f. (HINDI—*Chire kutki*; TAM.—*Kadai kanai, pattupillu*; RAJASTHAN—*Kuri*) are thought to be the wild forms of *P. miliare* distributed over the whole of India. They are said to be useful as fodder plants. The grains (niacin content, 1.7 mg./100 g.) are said to be used in Assam for the preparation of a slightly alcoholic beverage (Bor, 1960, 329; Sen Gupta, *Indian J. appl. Chem.*, 1958, 21, 45).

P. trypheron Schult. (TEL.—*Adavi sathagaddi*; TAM.—*Samai karunai*; KAN.—*Kadukarai samai hullu*; BOMBAY—*Bhatur*; U.P.—*Mijhi*), a tufted annual, up to 90 cm. tall, occurring throughout India, is a constituent of pasture lands, borders of cultivated fields and other grassy waste places. It is said to be liked by cattle. The seeds which resemble white Italian millet (*Setaria italica*) are said to be used for bread in times of scarcity (Ranga Acharyar, 96; Bor, 1960, 331; Gammie, *Rec. bot. Surv. India*, 1902, 2, 194).

P. turgidum Forsk. (RAJASTHAN—*Munt, murugas*), a perennial grass with a thick rootstock and hard, smooth and polished stems, is recorded from the sandy and arid regions of Rajasthan and Saurashtra. The grass is remarkably drought resistant and is very valuable as a sand binder. When green, the grass is largely eaten by all animals, but when dry only camels and donkeys browse on it. In Sahara, the grains are said to be collected for food and the stiff straw used for making mats (Fl. Egypt, I, 435; Dalziel, 535; Whyte *et al.*, 1959, 352).

Besides the above, a few species of *Panicum* have been introduced into this country. *P. coloratum* Linn., a stoloniferous perennial from tropical Africa, where it grows in wet and often waterlogged soils forming large tussocks, is said to have distinct possibilities as a fodder plant and soil binder. *P. laevifolium* Hack., a vigorous annual, has been introduced from S. Africa, where it is said to make an excellent hay relished by stock. *P. virgatum* Linn. syn. *P. glaberrimum* Steud.; *P. pruinatum* Bernh. ex Trin. is a vigorous, sod-forming perennial grass, 90–150 cm. high, which has been introduced from U.S.A., and is said to have proved successful as a fodder grass. Its young growth is palatable and hay is of fair quality (Bor, 1960, 325, 327, 331; Meredith, 334–35, 662; Whyte *et al.*, 1959, 353).

Panicum spp.—see *Brachiaria, Digitaria, Echinochloa, Hymenachne, Paspalidium, Saccolenis, Setaria, Urochloa*

Panther—see **Leopards**

Papain—see **Carica**

PAPAVER Linn. (*Papaveraceae*)

A large genus of annual to perennial herbs with milky latex, commonly known as Poppies, distributed chiefly in the temperate and sub-tropical regions of the Old World. Six species occur in India, of which 3 are introduced. *P. somniferum* is cultivated as the chief source of commercial Opium.

A number of species of *Papaver* are grown as ornamental plants for their exquisite bright flowers, ranging in colour from white to almost black, through various shades of yellow, pink, orange, scarlet and crimson. The species most commonly grown are: *P. nudicaule* (Iceland Poppy), *P. orientale* (Oriental Poppy), *P. rhoeas* (Corn Poppy) and *P. somniferum* (Opium Poppy). Many varieties, strains and hybrids of poppies with single or double flowers and some with fringed petals have been raised. Most of the poppies are grown as annuals; Oriental poppy is, however, perennial and is useful for borders and rock gardens [Bailey, 1947, III, 2455–58; Desai, *Indian Fmg*, N.S., 1956–57, 6(9), 24; Gopalaswamiengar, 454; Bailey, 1949, 425; Bailey & Bailey, 531; Chittenden, III, 1479].

Poppies can be cultivated with little care in open situations and fairly rich loamy soil. They are propagated by seeds which are sown broadcast *in situ*, as seedlings do not transplant well. Young seedlings are thinned out 15–30 cm. apart. Flowers appear after 1½–2 months of sowing seeds. The perennial species, *P. orientale*, can be propagated also by root cuttings (Gopalaswamiengar, 454–56; Desai, loc. cit.; Bailey, 1947, III, 2456; Chittenden, III, 1479).

P. argemone Linn.

Fl. Br. Ind., I, 117; Kirt. & Basu, I, 125.

An annual herb indigenous to Europe and the Mediterranean region, and commonly grown in gardens in India. Leaves bipinnatisect with acute lobes; flowers pale scarlet; capsules oblong-elliptical.

An infusion or a syrup of the petals is used in Spain as a sudorific. The flowering plant contains 0.15% of alkaloids including rhoeadine, protopine

PAPAVER

and an unidentified alkaloid (m.p. 300° decomp.). Four anthocyanins named cyanidin-A (probably cyanin), cyanidin-B (probably chrysanthemin), pelargonidin-B and pelargonidin-C have been isolated from the flowers (*Chem. Abstr.*, 1960, **54**, 18884; Acheson *et al.*, *Nature, Lond.*, 1956, **178**, 1283).

P. dubium Linn.

D.E.P., VI (1), 16; Fl. Br. Ind., I, 117.

An annual herb, 30–60 cm. high, found in the western Himalayas from Kashmir to Garhwal. Leaves sessile, pinnatifid; flowers red with a dark spot at the base of petals; fruit an ovoid capsule, smooth; seeds numerous, small, kidney-shaped.

The plant is reported to be used in homocopathy. The petals are sudorific. In Australia, *P. dubium* has been suspected of causing dermatitis in cattle with peeling off of the skin of the udder and nose, and salivation (Hoppe, 634; Kirt. & Basu, I, 125; Connor, *Bull. Dep. sci. industr. Res. N.Z.*, No. 99, 1951, 22).

The latex from the immature capsules contains two alkaloids, viz. aporeine ($C_{11}H_{16}O_2N$, m.p. 88–89°) and aporeidine (m.p. 176–78°), and meconic acid. Aporeine is reported to be a tetanizing poison showing a general resemblance to thebaine in action; it also produces a burning and numbing sensation on the tongue. According to recent investigations, the plant contains rhoeageneine as the principal alkaloid besides rhoeadine, protopine and two unidentified alkaloids (m.p. 159–61° and 243–45° decomp., resp.). The petals contain cyanidin-B and pelargonidin-C (Hoppe, 633–34; Henry, 275–76; Chopra *et al.*, 171; Boit & Flentje, *Naturwissenschaften*, 1960, **47**, 180; *Chem. Abstr.*, 1962, **57**, 5974; Acheson *et al.*, *Nature, Lond.*, 1956, **178**, 1283).

P. nudicaule Linn. ICELAND POPPY

Fl. Br. Ind., I, 117; Blatter, I, 28, Pl. 8, Fig. 2 & 3.

A perennial hairy herb, 25–30 cm. high, found in Gulmarg (Kashmir) at altitudes of 3,300–3,600 m.; it is commonly treated as an annual in gardens. Leaves radical, long-petioled, ovate or oblong, pinnately lobed, hairy; flowers white, yellow, orange or red; fruit an ovoid capsule, bristly.

The flowers and capsules are mildly diaphoretic. The plant is reported to be poisonous to sheep in Australia. It contains a cyanogenetic glucoside and an emulsin-like enzyme. Plants with yellow flowers are more cyanogenic than those with red or white flowers. Fresh leaves yield 3.1–5.1 mg./100 g. of hydrocyanic acid. The flowers contain an anthocyanin, nudicaulin chloride ($C_{30}H_{48}O_{16}NCl$) (Kirt.

& Basu, I, 128; Connor, *Bull. Dep. sci. industr. Res. N.Z.*, No. 99, 1951, 24; Wehmer, I, 387; Mayer & Cook, 233).

P. orientale Linn. ORIENTAL POPPY

Fl. Br. Ind., I, 117; Kirt. & Basu, I, 127; Bailey, 1947, III, Fig. 2752 & 2753.

An erect perennial herb, 60–90 cm. high, indigenous from Mediterranean region to Iran, and grown in gardens in India. Leaves pinnatipartite: segments oblong-lanceolate, serrate; flowers scarlet with a black violaceous spot at the base of petals; capsules glaucous, sub-globose; seeds orbicular-reniform, brown, broadly striate, foveolate.

The petals are sudorific. The plant contains 0.16% of alkaloids which include thebaine ($C_{19}H_{21}O_3N$, m.p. 193°), isotherbaine (m.p. 203–04°), protopine ($C_{20}H_{21}O_3N$, m.p. 207°), glaucidine (m.p. 209–10°), and oripavine ($C_{18}H_{21}O_3N$, m.p. 200–01°). Presence of considerable amounts of potassium nitrate has also been reported. Thebaine is reported to be the predominant alkaloid during active growth of the plant, but at maturity, the plant contains mostly isotherbaine. Isotherbaine stimulates and later depresses the central nervous system (Wehmer, I, 386; *Chem. Abstr.*, 1936, **30**, 1380; Henry, 266, 276; Manske & Holmes, IV, 135; VI, 17; Dawson & James, *Lloydia*, 1956, **19**, 59).

P. rhoeas Linn. CORN POPPY

D.E.P., VI (1), 16; Fl. Br. Ind., I, 117.

HINDI.—*Lalpost, post, postekebija*; BENG.—*Lalposht*; MAR.—*Tambadakhasakhasa*; GUJ.—*Lala, lalkhaskhas*; TEL.—*Erragassagassala, errapostakaya*; TAM.—*Sigappuppostaka, sivappugashagasha*; KAN.—*Kempu gasgase, kemipukhasakhasi*; MAL.—*Shivappupostakachedi, chovannakashakasha*.

An erect, branched, very variable annual, 30–60 cm. high, found in fields in Kashmir. Leaves pinnately divided: segments more or less cut, awned; flowers scarlet, with a dark eye; capsules sub-globose, smooth; seeds dark brown.

P. rhoeas is commonly grown in gardens and one of its strains, the well known Shirley Poppy, is the most popular of ornamental poppies. It has flowers with exquisite shades and without any blotch at the base of petals.

The petals are mucilaginous and bitter. They are expectorant and have been used for cough or hoarseness; they also possess sudorific, sedative and anodyne properties. The fresh petals are used for the preparation of galenicals. Syrup or tincture made out



FIG. 99—PAPAVER RHOEAS—IN FLOWER AND FRUIT

of petals can be used for colouring medicines and food materials to which they impart a red colour and a bitter flavour. From an infusion of the petals, a test indicator has been prepared which turns red with acids and blue with alkalies. The petals are reported to contain a dark red pigment, namely inecocyanin chloride (cyanidin chloride-3-gentibioside; $C_{21}H_{21}O_{16}Cl$; yield, 18%, dry basis) and another cyanidin derivative. Later investigations have revealed the presence of cyanidin-B and pelargonidin-C in the flowers (Hoppe, 634; Kirt. & Basu, I, 123; Wehmer, I, 386; Wallis, 162; Steinmetz, II, 331; *Chem. Abstr.*, 1932, **26**, 1393; Forsyth, *Bull. Minist. Agric., Lond.*, No. 161, 1954, 24; *Hort. Abstr.*, 1951, **21**, 528; Perkin & Everest, 293; Acheson *et al.*, *Nature, Lond.*, 1956, **178**, 1283).

All parts of the plant possess toxic properties, especially the capsules; the latex from the capsules is narcotic and slightly sedative. As the toxin is not destroyed by drying, the corn poppy can be dangerous in hay and cases of poisoning of horses and cattle by this plant have been reported in Europe. Symp-

toms of poisoning are colic, constipation, tympanitis in cattle and raging fits of fury in horses. The bruised leaves are applied to the skin when stung by a bee or wasp. Aqueous extracts of the plant exhibit antibiotic activity (Connor, *Bull. Dep. sci. industr. Res. N.Z.*, No. 99, 1951, 25; Gardner & Bennetts, 30; Chopra *et al.*, 172; Caius, *J. Bombay nat. Hist. Soc.*, 1938-39, **40**, 522; *Chem. Abstr.*, 1959, **53**, 8310).

An alkaloid rhoeadine ($C_{21}H_{21}O_6N$, m.p. 256-57° *in vacuo*) is present in all parts of the plant including roots (0.015%), leaves, flowers (0.031%), and capsules (0.035% in the unripe stage). The capsules contain also the alkaloids morphine, thebaine and narcotine, and meconic acid. Protopine and coptisine, besides a number of other phenolic and nonphenolic, crystalline and amorphous bases have been reported in the roots and aerial parts. A more recent examination confirmed the presence of rhoeadine and protopine in the aerial parts of the plant; in addition, rhoagenine (m.p. 240-43°) and a number of uncharacterized alkaloids were isolated (Wehmer, I, 386; Henry, 275; Chopra *et al.*, 172; *Chem. Abstr.*, 1959, **53**, 1640, 19301; 1962, **57**, 5974).

The seeds yield c. 35% of a yellow acrid oil similar to poppy seed oil and having the following range of constants: sp. gr. 4° , 0.9201-0.9221; n_{D}^{20} , 1.4681-1.4696; sap. val., 186-191; iod. val., 132-138; acid val., 5-14; thiocyanogen val., 77-79; Hehner val., 95.3; viscosity at 20° , 50.7 cp.; and unsapon. matter, 0.3-1.3%. A sample of the oil had the following fatty acid composition: stearic, 2.6; palmitic, 5.8; oleic, 27.6; and linoleic, 64.0%. The unsaponifiable matter contains sitosterol and also probably ceryl alcohol (Eckey, 448-49; Hoppe, 634; Nayar, *J. Bombay nat. Hist. Soc.*, 1954-55, **52**, 515; Mensier, 421; *Chem. Abstr.*, 1950, **44**, 11126).

P. somniferum Linn. OPIUM POPPY, WHITE POPPY
D.E.P., VI (1), 17, 150; C.P., 845; Fl. Br. Ind., I, 117.

SANS.—Ahifen, chosa, khasa; ARAB.—Abunom, asium, bizrulkhashkhash; PERS.—Asiun, khashkhesh, kokner; HINDI.—Afim, afyun, kashkash, post; BENG.—Pasto; MAR.—Aphu, khuskhus, posta; GUJ.—Aphina, khuskhus, posta; TEL.—Abhini, gasalu, kasakasa; TAM.—Abini, gashagasha, kasakasa, postlaka; KAN.—Afim, biligasgase, khasakhasi; MAA.—Afim, kashakhasa.

(These names are used for the plant, capsules, seeds and opium).

An erect, rarely branched, usually glaucous

annual, 60–120 cm. high. Leaves ovate-oblong or linear-oblong, amplexicaule, lobed, dentate or serrate; flowers large, usually bluish white with a purple base or white, purple or variegated; capsules large, 2.5 cm. diam., globose, stalked; seeds white or black, reniform.

P. somniferum was previously believed to have originated through cultivation from *P. setigerum* DC. which grows wild in the Mediterranean region. Recent cytological studies, however, have shown that *P. somniferum* is diploid ($n=11$) and could not have originated from *P. setigerum*, a tetraploid ($n=22$). They are, at best, closely related but distinct species. The centre of origin of the opium poppy lies in the western Mediterranean region, whence, as early as the tertiary period, it spread through the Balkan Peninsula to Asia Minor [Farmilo *et al.*, *Bull. Narcotics*, 1953, 5(1), 26; Vesselovskaya, *Bull. appl. Bot. Pl.-Breed.*, 1933, suppl. 56, 184–88; Kuzmina, *Zuchter*, 1937, 9, 53].

Opium poppy is cultivated for the production of opium and for the poppy seeds. Poppy cultivation for opium has been carried on in Italy, Greece and Asia Minor since antiquity. The spread of its cultivation through Asia appears to have been primarily due to the Arabs. At present, opium poppy is cultivated mainly in India, Turkey and U.S.S.R. It is also grown to a small extent in Yugoslavia, Bulgaria, Afghanistan, Pakistan and Japan. Iran, which was once a major producer of opium, prohibited opium production in 1955. In Central Europe, opium poppy is grown primarily for its seeds, and the production of opium has never been taken up; since 1930, however, mature, seedless poppy capsules (Poppy Straw) have gradually been replacing the imported opium as raw materials for the extraction of morphine and the manufacture of opiates [Kussner, *Bull. Narcotics*, 1961, 13(2), 1; Kusevic, *ibid.*, 1960, 12(2), 5].

In India, cultivation of poppy for opium was established by the early 16th century and was a considerable source of revenue to successive Governments. Opium was freely sold as an intoxicant within the country and exported for the same purpose to the Far Eastern countries, particularly China. China was a big market for Indian opium, and this resulted in the high acreage under opium poppy in the early part of the present century. The flagrant misuse of opium and its deleterious effects physically, mentally and morally became so widespread, that it became a serious social problem in many countries. As a result of agreement with China to progressively

reduce the export of opium to that country, the total area under poppy cultivation declined from 311,210 ha. (769,000 acres) in 1903 to c. 50,000 ha. (123,000 acres) in 1960–61. Further, the Government of India decided in 1949 to stop opium consumption for non-medical and quasi-medical uses in the country completely by 1958–59 [*54th Rep., Estimates Comm.*, 1958–59, Minist. Finance (Dep. Revenue), Narcotics Dep., Govt. India, 1; Chopra & Chopra, *Bull. Narcotics*, 1955, 7(3–4), 1; Chopra, 1958, 207].

The cultivation of opium poppy in India is controlled by the Government and is now confined to Uttar Pradesh, Madhya Pradesh and Rajasthan. Negligible quantities are also grown in Jammu & Kashmir. Cultivation in Himachal Pradesh has been completely banned since 1954–55, as it is difficult to control in this hilly region the surreptitious removal of opium by the licensed poppy cultivators. The area under cultivation of opium poppy is divided into 12 opium divisions. They are Faizabad, Bara Banki, Bareilly and Shahjahanpur in U.P., Neemuch I & II, Mandsaur I & II and Ratlam in M.P., and Chitorgarh, Jhalawar and Kotah in Rajasthan. Each division includes a number of districts. The area under poppy cultivation and the production of opium in India are given in Table 1 [*Rep. on the Operations of the Opium Dep. for the year ending Sept. 30, 1954*, Minist. Finance (Revenue Division), Govt. India, 1; *54th Rep. Estimates Comm.*, 1958–59, Minist. Finance (Dep. Revenue), Narcotics Dep., Govt. India, 7].

There are numerous varieties of *P. somniferum* of which two are under cultivation for the production of opium. They are var. *album* DC. with ovate-globose capsules devoid of apertures, cultivated in India, parts of Iran, and Yugoslavia, and var. *glabrum* DC. with red, purple or variegated flowers and almost spherical capsules, dehiscing through openings below the stigmatic lobes, cultivated in Asia Minor, Egypt and parts of Iran. Var. *nigrum* DC. with open capsules is particularly cultivated for seeds in Europe. There are several forms of var. *album* in cultivation in India: the form with white flowers and white seeds is grown in Uttar Pradesh; the form with red or purple flowers is grown in Madhya Pradesh and Rajasthan (Malwa); and a parti-coloured form is occasionally met with in the Himalayas.

Various races of opium poppy are grown in India, but no comprehensive classification has so far been evolved. They vary in size and shape of plants, leaves, petals, capsules, and in the drug-yielding



Reg. Res. Lab., Jammu

PAPAVER SOMNIFERUM VAR. SOMNIFERUM — IN FLOWER AND FRUIT

TABLE I—AREA UNDER CULTIVATION OF OPIUM POPPY AND PRODUCTION OF OPIUM IN INDIA*

	Area (thousand hectares)					Production (thousand kg.)				
	Madhya Pradesh	Uttar Pradesh	Rajasthan	Himachal Pradesh	Total	Madhya Pradesh	Uttar Pradesh	Rajasthan	Himachal Pradesh	Total
1949–50	8.4	7.0	4.4	1.0	20.8	45.3	21.0	37.4	2.8	106.5
1950–51	10.5	9.3	7.5	0.9	28.2	237.2	159.1	150.4	3.0	549.7
1951–52	4.1	13.6	3.9	0.9	22.5	59.8	203.2	70.9	3.5	337.4
1952–53	12.1	12.5	8.4	0.8	33.8	248.3	201.6	171.6	3.1	624.6
1953–54	8.1	7.8	5.1	0.7	21.7	177.9	134.8	121.1	1.7	435.5
1954–55	7.6	5.1	4.8	..	17.5	140.8	115.4	102.9	..	359.1
1955–56	7.5	5.0	4.9	..	17.4	152.7	86.6	105.3	..	344.6
1956–57	9.0	7.9	7.1	..	24.0	194.5	140.4	148.4	..	483.3
1957–58	11.1	7.5	7.2	..	25.8	301.9	155.4	198.5	..	655.8
1958–59	13.6	7.6	8.8	..	30.0	356.1	176.3	228.7	..	761.1
1959–60	17.4	10.2	13.7	..	41.3	392.3	202.8	317.8	..	912.9
1960–61	20.7	13.9	16.5	..	51.1	308.8	297.5	305.1	..	911.4
1961–62	15.6	15.3	14.5	..	45.4	374.7	276.5	318.2	..	969.4

* Rep. Operations of the Narcotics Dep., Minist. Finance, Govt. India.

Years refer to Opium Year, Oct.–Sept.

Cultivation of opium poppy in Himachal Pradesh has been banned since 1954–55.

capacity. Sometimes, there is marked difference in the colour and quality of the drug obtained, its morphine content, and in the ratio of the principal alkaloids present in it. Since cross-pollination is common, a crop of opium poppy contains a wide range of forms composed of hybrids. Broadly speaking, various races of Indian opium poppy may be separated into well defined groups based on the colour and texture of the capsules. Capsules of one group are opaque green in colour, in deeper or paler shades; this comprises the *Subza-dheri* races. The other group has glaucous capsules, more or less densely coated with an opaque white powder; this is the *Sufaid-dheri* group. The races are known in India by their local names. Among the races commonly grown in Uttar Pradesh are *Teyleah* or *Telia*, *Haraina*, *Hariala* or *Herera*, *Sufaid-danthi* or *Katha Bhabutia*, *Kutila*, *Katila* or *Kotila* or *Chansura*, *Ghanghabaha*, *Chirrah* or *Bhagbhora*, *Choura Kutila*, *Kaladanathi*, *Karria*, *Damia*, *Kalidanathi* or *Kalidandi*, *Subza Kaladanathi* or *Haraina Kalidanathi*, *Kalidanathi Baunia*, *Monoria*, *Dheri-danthi*, *Variegated poppy*, *Sufaid-danthi Monoria*, *Monaria Teyleash*, *Sandpha* or *Dhadhua* or *Bhabhua*, and *Sahbania*. The races grown in Madhya Pradesh and

Rajasthan include *Bhatphoria* or *Dhaturia*, *Galania*, Hybrid of above two races, *Ramzatak*, *Telia*, *Ghotia*, *Chaglia*, *Kasturi* or *Tejani*, *Kantia* and *Gabra* [Hunter & Leake, 236; Asthana, Bull. Narcotics, 1954, 6(3–4), 1; Information from Govt. Opium & Alkaloid Works, Ghazipur, U.P.].

CULTIVATION

The cultivation of opium poppy in India is entrusted to cultivators under licences issued by the district opium officers of different areas. The licensed cultivators undertake, on behalf of the Government, to sow the poppy, lance the capsules, collect the latex and deliver it at the weighing centres at a price fixed by the Government. The programme for cultivation is drawn up every year in advance in accordance with the requirements of opium for legitimate oral consumption in the country, export, and manufacture of alkaloids for sale in India and to the extent possible for export plus a reasonable reserve [Asthana, loc. cit.; 54th Rep., Estimates Comm., 1958–59, Minist. Finance (Dep. Revenue), Narcotics Dep., Govt. India, 6].

Climate & Soil—Opium poppy grows in varying climates but it cannot endure extreme cold. In cold climate, opium yield is greatly diminished. Dull,

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cloudy or rainy weather tends to reduce not only the quantity, but also the quality of the drug. High or gusty winds during the opium season are deleterious because they dry up the plant and thus check the exudation of latex. Hailstorm ruins the crop, while a heavy rainfall between the period of lancing of the capsules and the collection of the latex leaves little or nothing for collection. Frost is sometimes very destructive to the crop. Opium poppy is grown in almost all kinds of soil, but it prefers a sandy loam [Bull. Narcotics, 1953, 5(3), 9; Asthana, loc. cit.; Kapoor, Indian Fmg. N.S., 1961-62, 11(7), 8].

Culture—Opium poppy is cultivated as a rabi crop and often follows a crop of maize or other kharif crops. Land is prepared in September by repeated ploughing and harrowing and brought to a fine tilth; 25-37 cartloads of farmyard manure are added per hectare. Penning sheep and goats on the field is preferred. Application of phosphate and nitrogenous fertilizers has a beneficial effect on opium yield. Experiments conducted in U.S.S.R. have shown that

application of superphosphate in two stages, viz. during ploughing and during cultivation, has a particularly pronounced effect on opium yield. During the initial period of development, poppy crop needs heavy phosphate feeding and less nitrogen and potash. But later during the growing period it needs a considerable amount of nitrogenous feed which increases not only the opium yield but also its morphine content. Before sowing, the field is laid out into beds for convenience of irrigation and weeding. Seeds mixed with earth or ashes are sown broadcast in October-November at the rate of c. 3.5 kg./ha. Frequent light irrigation is necessary until the seedlings are fairly established. When the seedlings are 5-7.5 cm. high, they are thinned out 20-25 cm. apart and weeded [Mollison, III, 246; Mukerji, 320; Annett & Singh, Mem. Dep. Agric. India, Chem., 1925-26, 8, 27; Sheberstov, Bull. Narcotics, 1956, 8(3), 42; Roberts & Kartar Singh, 500].

Diseases & Pests—Opium poppy is susceptible to



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FIG. 100—PAPAVER SOMNIFERUM VAR. SOMNIFERUM—CROP IN FLOWER

downy mildew [*Peronospora arborescens* (Berk.) de Bary], root rot (*Rhizoctonia* sp.) and the thread mould (*Dactylium roseum* Berk.=*Trichothecium roseum* Link); the thread mould also forms a rosy covering on the surface of opium when it is left undisturbed for considerable time. A number of other fungi have also been reported on the poppy plant (Butler, 344; Brooks, 109; Asthana, loc. cit.; *Indian J. agric. Sci.*, 1950, 20, 107).

Poppy plants suffer seriously from leaf curl disease, supposed to be caused by a virus, the symptoms of which are identical to potato and tobacco mosaic. The disease is checked by plucking the diseased plants and burning them. Plants with gangrene and root canker are also occasionally met with (Asthana, loc. cit.).

Opium cut-worm (*Agrotis suffusa* Hübn.) does great harm to the young opium poppy. Cut-worms remain burrowed in the soil during the day and eat away the leaves during night; the affected plants die after a few days. They are controlled by flooding the fields with water when the cut-worms float on the surface and are picked up by birds. Caterpillars do serious damage to the growing crop. Irrigating the fields dislodges them from their soil haunts when they are eaten by crows and myna. *Heliothis armigera* Hübn. is another opium pest which develops from the egg while the plant is young and subsists at first on its tender leaves. As the plant matures, it eats its way up the stem, and finally bores into and eats the interior of the capsules. A small insect and a cricket (*Gryllotalpa vulgaris* Latr.) are reported to cause some damage to the crop. Poppy seeds for sowing are stored in vessels containing camphor to prevent them from insect attack. *Orobanche aegyptiaca* Pers. (Broom-rape), a root parasite, does considerable damage to the poppy crop (Asthana, loc. cit.).

Harvesting Opium is harvested by incising the capsules at a particular phase of plant's growth known as industrial maturity. The plant flowers 75–80 days after germination of seeds, and the petals fall off 24–72 hours after the opening of buds. The capsules take another 8–10 days to become fully swollen, when they are ready for lancing (scarification). The period of collection of opium extends from the end of January to April; in the hills it is extended till June. For lancing, the field is usually divided into three portions so that each portion gets a chance for scarification of the capsules every third day. Lancing operation commences when 5–10% of

the capsules in a portion of the field are ready for the purpose. The capsules are incised with a special type of knife with 3 or 4 small blades designed to ensure uniformity in the depth of incisions. Usually, each capsule is lanced 3 or 4 times and sometimes as many as 8 to 10 times until no more latex exudes. The incisions are usually made vertically from below upwards or horizontally round the capsule near the middle. Lancing is done after midday and the exuding latex is allowed to remain on the capsules overnight, during which time it coagulates and becomes somewhat thicker and slightly darker in colour. The latex varies in colour from milky white and smoky white through pale pink to a very bright pink. In the morning, usually before sunrise, the coagulated latex (raw opium) is collected from the surface of capsules with a blunt-edged small iron scoop; the capsules are then cleaned by rubbing them with the thumb (Kapoor, loc. cit.; Information from Govt. Opium & Alkaloid Works, Ghazipur, U.P.; Annett *et al.*, *Mem. Dep. Agric. India, Chem.*, 1921–23, 6, 1).

Yield of opium—The yield of opium varies from place to place depending on various factors, such as nature of soil, climate and weather, the number and mode of lancing of capsules, etc. Each capsule gives a maximum yield of latex at the first lancing and the yield decreases with each successive lancing. Use of a knife having 6 blades instead of 3 or 4 increases the total yield of opium per capsule. Terminal capsules yield more opium of considerably higher morphine content than the lateral ones. Yields varying from 28 to 48 g. per 1,000 capsules have been reported for the first lancing. On an average, the yield is 13–18 kg./ha. (12–16 lb./acre). Yields as high as 27–56 kg./ha. (24–50 lb./acre) are also recorded (Evcim, *Amer. J. Pharm.*, 1954, 126, 40; Annett *et al.*, *Mem. Dep. Agric. India, Chem.*, 1921–23, 6, 1; Annett, *ibid.*, 1921–23, 6, 61; Leake & Annett, *Agric. J. India*, 1920, 15, 124; Kapoor, loc. cit.; Roberts & Kartar Singh, 500; Mollison, III, 247; Mukerji, 321).

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RAW OPIUM

Collection The produce of each day's lancings (raw opium) from each field is stored separately in metal or earthen pots; the pots are kept in a tilted position or provided with a hole at the bottom to allow the moisture to drain off. The opium is turned over with hand at intervals of c. 10 days to give it a uniform consistency. In humid regions, during this

period, a shining, oily, resinous semi-solid mass, called *pasewa*, is separated from the raw opium; *pasewa* is strongly acidic with a peculiar smell and consists of the most soluble constituents of opium dissolved in dew or in moisture absorbed from the atmosphere. After turning over for the required period, the raw opium is dried in sun on earthen plates. As the product of first lancing contains a higher percentage of morphine than of the subsequent lancings the cultivators collect, store and deliver this separately (Information from Govt. Opium & Alkaloid Works, Ghazipur, U.P.; *Bull. imp. Inst., Lond.*, 1915, 13, 507).

The raw opium received by the district opium officers is tested for its purity and consistency. It is then classified into the following categories: XXX (79, 80, 81 and above), XX (76, 77, 78), X (73, 74, 75), I (70, 71, 72), II (67, 68, 69), III (64, 65, 66) and so on down to class VII; the figures in brackets indicate degrees of consistency, i.e. the percentage of solid matter, the rest being moisture. Precautions are taken to check adulteration with sand, earth, sugar, molasses, tannin, gum and well-pulverized starch. After the opium has been classified, it is stored category-wise in double bags—inner one of canvas and the outer of jute sacking. Opium of low consistency (<64°) is stored in earthen jars. The cultivators are paid at the rates fixed by the Government of India in terms of 70° consistency. Such opium is called *damdeta* opium, meaning opium for which payment has been made. All the opium received by the district opium officers from the cultivators is despatched to the Government Opium & Alkaloid Works, Ghazipur, U.P. [Asthana, *Bull. Narcotics*, 1956, 8(2), 31].

The main operations of the Ghazipur factory are receipt and storage of opium, manipulation and manufacture of excise and export opiums, packing of opium cakes, manufacture of various opium alkaloids, and disposal of contraband opium. The Government Opium Factory, Neemuch, M.P., is no more a manufacturing concern; it acts mainly as a warehouse for stocks of opium earmarked for the supply to Madhya Pradesh and Rajasthan. During 1957-58, however, with a view to meet the demand of opium for export, the factory undertook drying operations of opium collected from adjoining areas to supplement the activities of the Ghazipur factory [Vardhan, *Bull. Narcotics*, 1956, 8(2), 35; Asthana, loc. cit.].

Storage—Raw opium begins to arrive at the

Government Opium & Alkaloid Works, Ghazipur, about the second or third week of April in bags or jars. Samples taken from the consignments are chemically examined and the jars and bags are marked with the grade, consistence and the morphine contents; they are stocked in separate vats according to the morphine strength (M.S.). Opium in the factory is classified into four grades, viz. A (M.S., >12%), B₁ (M.S., between 11 and 12%), B₂ (M.S., between 10 and 11%), and B₃ (M.S., between 8 and 10%). Opium admixed with impurities is termed as inferior opium, and stored and graded as 'C' (Vardhan, loc. cit.).

(Opium requires careful storage. In the past, Indian opium, compared to that of other countries, appears to have suffered more morphine loss during preparation and storage. Conflicting views are held with regard to the loss of morphine. The morphine content does not decrease if opium is stored under anaerobic conditions even in the moist state. If, however, it is dried at 60° and stored in contact with air it suffers a rapid loss of morphine. When dried at 98-100° and stored out of contact with air, the loss of morphine is not appreciable. It has been reported that no morphine is lost during first five days when opium is kept at 97-98°, but prolonged heating leads to a progressive loss of morphine. An enzyme, roxidase, has been isolated from opium which may be the factor responsible for the decomposition of morphine (Trease, 296; Dunncliff *et al.*, *Proc. nat. Inst. Sci. India*, 1935, 1, 107; Annett & Singh, *J. Soc. chem. Ind., Lond.*, 1918, 37, 315 T).)

Opium is sometimes found to be covered with mould under moist conditions but this does not markedly affect its morphine content. The fungi recorded so far in opium in India and Turkey are *Scopulariopsis brevicaulis* var. *glabra* Thom. and species of *Aspergillus*, *Fusarium* and *Penicillium*. The fungicides tried include Agrosan GN, Ceresan T, Verdesan, Hortexan and Formalin [Eltutar & Ignecliler, *Bull. Narcotics*, 1958, 10(4), 12; Eltutar, *ibid.*, 1960, 12(3), 25; Dunncliff *et al.*, loc. cit.]

PROCESSED OPIUM

At the Government Opium & Alkaloid Works, Ghazipur, three kinds of opium are processed, viz. Excise (Abkari) Opium, Export Opium (formerly known as Provision Opium) and Indian Medical Opium (I.M.O.) Powder and Cake. In consonance with the policy of the Government of India, the manufacture of excise opium is limited to the barest requirements for quasi-medical purposes. Raw opium

is processed and supplied to meet the requirements of manufacturers abroad for medical and scientific purposes. Indian medical opium powder and cake are manufactured primarily to meet the requirements of the Government medical store depots and other pharmaceutical concerns for purely medical purposes. Table 2 gives the production of excise and export opiums and of Indian medical opium. In addition, some quantities of illicit opium are confiscated every year and released for licit use (Vardhan, loc. cit.).

Excise (Abkari) opium—For the preparation of excise opium, raw opium weighing c. 75 kg. is laid out in open wooden trays for sun-drying till its consistence is raised to 90°. Each such lot of opium at 90° consistence spread out in a tray is called *dhundhia*. After the receipt of the test report from the opium chemist, the passed *dhundhias* are cut into small blocks each weighing 1.0 kg. or 0.5 kg. as required. The cut pieces are then sent to the press to be shaped into cubical cakes stamped with the factory die plates. Each cake is then wrapped in two sheets of butter paper and tied with cotton tape embossed with the factory markings. The wrapped cakes are packed in chests, each containing two layers of 30 compartments each and a cake fitting exactly into each compartment. Chests of 56 kg. (60 seers), 28 kg. (30 seers), 14 kg. (15 seers) and 4.67 kg.

(5 seers) capacity are generally used (Vardhan, loc. cit.).

Export opium Export opium is generally manufactured in 1 kg. cakes. Slabs of 5 kg. or 10 kg. are also manufactured and supplied if desired by the purchasers. The manufacture of export opium is open to all grades of good opium according to the requirements of the buyers in terms of morphine content (Vardhan, loc. cit.).

Indian medical opium cake and powder

Medical opium cake is manufactured from raw opium of suitable grade or from opium of different grades blended together in appropriate proportions. The raw opium is spread thinly in stainless steel trays in order to avoid metallic contaminations and dried in the sun, the mass being frequently turned over to make it homogeneous. The consistence of the finished product is 90°. The mass is then cast into slabs of 1.0 kg. or 0.5 kg. The raw opium used is tested for its freedom from adulterants while the finished cake is tested for pharmaceutical requirements. I.M.O. powder is also made from tested, graded or blended raw opium. The consistence is raised on steam tables or in an oven to 100°. The mass is pulverized in stainless steel grinding machines and sieved. The powder thus obtained is tested to ensure that it conforms to pharmacopoeial standards.

TABLE 2—PRODUCTION OF EXCISE AND EXPORT OPIUMS AND INDIAN MEDICAL OPIUM (I.M.O.)[†]
(in kg.)

	Opium			I.M.O.		
	Excise [‡]	Export [‡]	Total	Cake [‡]	Powder [‡]	Total
1951-52	109,472	156,015	265,487	248	1,263	1,511
1952-53	128,022	134,255	262,277	391	1,391	1,782
1953-54	89,615	251,565	341,180	365	1,851	2,216
1954-55	87,190	203,231	290,421	455	2,045	2,500
1955-56	41,131	261,530	302,661	877	2,348	3,225
1956-57	33,107	372,996	406,103	639	809	1,448
1957-58	20,640	454,197	474,837	533	2,216	2,749
1958-59	54,904	493,799	548,703	1,010	2,404	3,414
1959-60	56,770	106,187	162,957	794	2,344	3,138
1960-61	4,565	230,738	235,303	433	2,744	3,177
1961-62	3,104	212,788	215,892	1,015	2,779	3,794

* Information from Minist. Finance (Dep. Revenue), Govt. India.

† Consistency of 90°. ‡ Consistency of 100°.

Years refer to Opium Year, Oct.-Sept

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It is packed in 5, 4, 2 and 1 kilogram sealed tin containers. The supply is regulated under the provisions of the Dangerous Drugs Act and Rules (Vardhan, loc. cit.).

In a process developed in U.S.S.R., mechanical drying is reported to give a powder with higher alkaloid content [Shevelev *et al.*, *Bull. Narcotics*, 1958, 10(2), 6].

ADULTERANTS

Opium is adulterated with fresh green parts of the plants, sand, ashes, seeds such as linseed, poppy-seed and leguminous seeds, tubers and roots, extracts of poppy, tobacco, datura, hemp, *Lactuca virosa*, *Glycyrrhiza glabra* and *Glaucium flavum* Crantz, gum arabic, tragacanth, salep, aloes, small stones, flowers of *Madhuca latifolia*, saccharine matter, vegetable oils, ghee and minute pieces of lead and iron. Opium is regarded as inferior if it has a blackish colour, a weak or empyreumatic odour, a sweet or slightly nauseous and bitter taste, a soft viscid or greasy consistency, a dull fracture, or an irregular heterogeneous texture due to the intermixture of foreign substances. It should not impart a deep brown colour to the saliva, nor leave a dark uniform trace when drawn over paper, nor form with water a thick viscid solution (U.S.D., 1955, 926).

OPIUM ALKALOIDS

Opium alkaloids and their salts are manufactured in India only by the Government Opium & Alkaloid Works, Ghazipur. The alkaloids manufactured conform strictly to the I.P., B.P., U.S.P., and other international standards. The methods of manufacture lay emphasis on the separation of morphine and codeine, the other alkaloids being considered as of secondary importance. The various processes involve concentration of aqueous opium extracts to a syrupy consistency and then precipitation of alkaloids from concentrated extracts. The products manufactured include morphine and codeine and their salts, narcotine, dionine (ethyl morphine hydrochloride), papaverine and its hydrochloride, papaveratum, thebaine and cotarnine hydrochloride. For details on extraction of opium alkaloids, refer Wlth India—Industrial Products, pt VI, 118–30.

CHEMICAL COMPOSITION

Fresh opium is a brownish, somewhat plastic solid, becoming tough and occasionally brittle on keeping and has a characteristic fruity odour. Opium is valued for the alkaloids it contains, the total alkaloid

content varying from 5 to 25% (generally 20%). A large number of alkaloids have been isolated from opium, of which at present 25 are known (Table 3). Morphine, codeine, thebaine, narcotine, narcine and papaverine are the chief opium alkaloids, and of these morphine is the most abundant and by far the most important. Morphine exists in combination with meconic and sulphuric acids in the form of salts readily soluble in water. Other alkaloids occur in opium partly in the free state and partly as salts (Thorpe, IX, 99; Annett *et al.*, *Mem. Dep. Agric. India, Chem.*, 1921–23, 6, 1; Merck Index, 756; Chopra *et al.*, 169; Henry, 178; U.S.D., 1955, 927).

The valuation of opium depends upon its morphine content which varies markedly in commercial samples. The morphine content in samples of opium from different countries ranges as follows: Indian, 3–15; French, 12–23; German, 9–15; Swedish, 12; Algerian, 14–17.8; Australian, 4–11; Japanese, 0.7–13; Chinese, 1.5–11; Egyptian, 0.3–8.0; Turkish, 5–14; Persian, 6–14; and Bohemian, 11–12%. Indian opium as prepared for smoking may contain 4–6% morphine, but that for medicinal purposes and the manufacture of alkaloids contains c. 12%. The relative proportions of other alkaloids also differ considerably. Indian opium is particularly rich in codeine and narcotine. The usual ranges of more important alkaloids in the Indian opium are: morphine, 9–14; narcotine, 3–10; codeine, 1.25–3.75; papaverine, 0.5–2.75; and thebaine, 1.5–3.0%; the rest of the alkaloids together constitute c. 1%. According to another source, the narcine content is 0.5–1.0%. A pure race of poppy plant grown at Kanpur yielded opium with morphine content as high as 20%. Table 4 summarizes the morphine, codeine and narcotine content of some important types of Indian opium (Chopra, 1958, 209; Annett, *Mem. Dep. Agric. India, Chem.*, 1921–23, 6, 61; Henry, 178–79; Dunncliff, *Nature, Lond.*, 1937, 140, 92; Wlth India—Industrial Products, pt VI, 125).

The morphine content of opium is found to vary with the number and position of capsules on the plant and the mode of lancing. It is maximum at the first lancing and then rapidly decreases in successive lancings (Table 5), the rate of decrease being appreciably influenced by the length of the incisions made on the capsules. The terminal or oldest capsule yields opium of a higher morphine content than the lateral ones on the same plant. Stunted plants produce opium with a lower morphine content, i.e. 11.6–12.7% (on dry basis) as against 15–16% in normal

TABLE 3—ALKALOIDS PRESENT IN OPIUM*

Alkaloid	Formula	m.p.
Morphine type		
Morphine	C ₁₇ H ₁₉ O ₃ N	254° decomp.
Codeine	C ₁₈ H ₂₁ O ₃ N	155°
Neopine	C ₁₈ H ₂₁ O ₃ N	127–27.5°
ψ-Morphine (pseudo- or oxymorphone)	(C ₁₇ H ₁₉ O ₃ N) ₂ .3H ₂ O	327° decomp.
Thebaine	C ₁₉ H ₂₁ O ₃ N	193°
Porphyroxine**	C ₂₃ H ₂₁ O ₇ N or C ₂₃ H ₂₁ O ₇ N	234–36° decomp.
Phthalide isoquinoline type		
Hydrocotarnine	C ₁₂ H ₁₅ O ₃ N. 0.5H ₂ O	55.5–56.5°
Narcotoline	C ₂₁ H ₂₁ O ₇ N	202° decomp.
L-Narcotine	C ₂₃ H ₂₃ O ₇ N	176°
Gnoscopine (dl-narcotine)	C ₂₃ H ₂₃ O ₇ N	229° or 232–33°
Oxynarcotine	C ₂₃ H ₂₃ O ₆ N	..
Narceine	C ₂₃ H ₂₃ O ₆ N.3H ₂ O	170°
Benzyl isoquinoline type		
Papaverine	C ₂₆ H ₂₁ O ₄ N	147°
Xanthaline (papaveraldine)	C ₂₆ H ₁₉ O ₅ N	210°
dl-Laudanidine	C ₂₆ H ₂₃ O ₄ N	166°
I-Laudanidine (tritopine, l-laudanidine)	C ₂₆ H ₂₃ O ₄ N	184–85°
Codamine	C ₂₆ H ₂₅ O ₄ N	126°
Laudanosine	C ₂₁ H ₂₇ O ₄ N	89°
Cryptopine type		
Protopine (macleine, fumarine)	C ₂₆ H ₁₉ O ₅ N	207°
Cryptopine	C ₂₁ H ₂₃ O ₄ N	220–21°
Unknown constitution		
Apocrine	C ₁₉ H ₁₉ O ₃ N	88–89°
Rhoeadine (?)	C ₂₁ H ₂₁ O ₆ N	256–57.5° (in vacuo)
Meconidine	C ₂₁ H ₂₃ O ₄ N	58°
Papaveramine	C ₂₁ H ₂₃ O ₆ N	128–29°
Lanthopine	C ₂₃ H ₂₃ O ₄ N	200° decomp.

* Henry, 178–79, 182, 187, 191, 193–94, 200–01, 205–07, 213, 215–16, 218–20, 259, 275, 295, 299; Chopra, 1958, 208; Manske &

** Holmes, IV, 30, 48, 57, 60, 185; Wehmer, I, 380.

** Genest & Farmilo, *J. Pharm., Lond.*, 1963, 15, 197.

TABLE 4—ALKALOID CONTENTS OF SOME TYPES OF INDIAN OPIUM*

Type	Morphine	Codeine	Narcotine
Posti	14.25	2.91	7.61
Katila	10.98–13.62	1.86–3.24	5.74–7.54
Baunia†	13.44, 9.57	3.93, 3.98	5.27, 4.52
Karria	13.27	3.35	7.01
Bharbharwa	12.54	3.24	6.19
Desi	12.07	3.72	4.86
Safed posta	11.83	2.81	5.96
Maghaiya	11.80	3.46	4.90

* Asthana, *Bull. Narcotics*, 1954, 6 (3–4), 1.

† Two samples.

TABLE 5—CONTENTS OF MAJOR ALKALOIDS IN OPIUM LATEX FROM
SUCCESSIVE LANCINGS OF THE SAME CAPSULE*

No. of lancing	Morphine	Codeine	Narcotine	Papaverine
	17.5	2.74	7.31	0.28
	14.4	3.08	5.56	0.57
	9.4	2.75	4.93	0.73
	7.5	2.52	4.43	0.53
	5.8	2.31	4.48	0.56

* Annett & Bose, *Mem. Dep. Agric. India, Chem.*, 1925–26, 8, 45.

plants. The percentage of codeine generally does not vary much in the opium from successive lancings of the same capsule. Narcotine content, however, decreases in a manner similar to that of morphine but the decrease is not so marked [Ginsburg, 3; Annett *et al.*, *Mem. Dep. Agric. India, Chem.*, 1921–23, 6, 1; Annett, *ibid.*, 1921–23, 6, 61; Annett & Singh, *ibid.*, 1925–26, 8, 27; Leake & Annett, *Agric. J. India*, 1920, 15, 124; Asthana, *Bull. Narcotics*, 1954, 6(3–4), 1; *Biol. Abstr.*, 1959, 33, 1909].

The physiology of the alkaloids in the opium plant is not clearly understood. The seeds, which are free

from alkaloids, on germination quickly give rise to narcotine, codeine, morphine and papaverine. Narcotine is reported to be the first alkaloid to appear three days after sprouting. Codeine, morphine and papaverine appear when the seedling is c. 7 cm. high. Morphine in the seedlings is present only in the root and from there it is probably translocated to other parts of the plant through the latex vessels. The total alkaloidal content of the plant slowly increases until the flowers appear, when there is a sharp increase lasting until the floral leaves fall. The concentration of morphine in different parts of the plant varies as follows: whole plant, 0.09–0.18; leaves, 0.06–0.07; stems, 0.01–0.03; capsules, 0.23–0.41; and straw, 0.07–0.19%. The average morphine content of young roots is reported to be 0.39% and of the old roots 0.13% (Manske & Holmes, VI, 16–17; I, 32; Thorpe, IX, 99; Madan & Mukerji, *J. sci. industr. Res.*, 1958, 17A, 224; U.S.D., 1955, 927; Henry, 176; Hoppe, 639).

The ash content of opium increases with successive lancing (2.3% in first lancing, 7.2% in sixth lancing). The ash contains: calcium, 7.79; phosphorus, 7.52; potassium, 28.04; sodium, 0.78; magnesium, 0.69; sulphur, 4.67; iron (Fe_2O_3) + aluminium (Al_2O_3), 5.17; carbon dioxide, 1.18; and sand and silica, 20.13% (Annett & Bose, *Mem. Dep. Agric. India, Chem.*, 1925–26, 8, 45).

Opium contains several acids including meconic (up to 10%), lactic (1–2%), malic, tartaric, citric, acetic, succinic, sulphuric and phosphoric acids which are present as salts; some free meconic acid is also present. Other constituents reported in opium are: protein, free amino acids, caoutchouc (5–10%), a brown wax (6–13.6%), volatile oil, colouring matter, dextrose (2.7–3.3%), pectin, ammonia and three neutral principles, viz. meconin (opianyl; $\text{C}_{10}\text{H}_{10}\text{O}_4$, m.p. 102°), meconoisin ($\text{C}_8\text{H}_{10}\text{O}_2$, m.p. 88°), and opionin. The presence of the enzymes protease, oxydases, maltase, invertase, urease and emulsin is also reported. Opium wax which is concentrated in the pericarp, has the following constants: m.p., >40°; iod. val., 152.5; sap. val., 114.5; R.M. val., 2; and unsapon. matter (containing sitosterol and ceryl alcohol), 28.7%. It probably consists of ceryl palmitate and sitosterolin and has no economic importance (Wehmer, I, 380; Hoppe, 637; Annett & Bose, *Mem. Dep. Agric. India, Chem.*, 1921–23, 6, 215; *Chem. Abstr.*, 1961, 55, 16914; U.S.D., 1955, 927, 929; Nadkarni, I, 903–04; Thorpe, IX, 115; Rakshit, *Sci. & Cult.*, 1942–43, 8, 16; Warth, 295–96).

Pharmacology of opium alkaloids—The characteristic action of principal opium alkaloids is their simultaneous depressing and exciting effect on the central nervous system. As the series is ascended in the order, morphine, papaverine, codeine, narcotine, and thebaine, the narcotic action diminishes and power of reflex stimulation increases until in the case of thebaine, a strychnine-like convulsant effect is exhibited (Henry, 259).

Morphine is a powerful analgesic and narcotic, and also has stimulant action. It especially depresses the thalamus, sensory cortex, respiratory and cough centres; it stimulates the spinal cord, the vagus and vomiting centres and the third nerve centre, and increases tone of involuntary muscles, especially in the sphincters of the alimentary tract. Morphine reduces secretions, with the exception of those of the skin glands. Skin vessels are dilated, but the circulation as a whole is little affected by therapeutic doses. Hypodermic administration of morphine salts (8–15 mg.) produces a euphoric effect within half an hour, characterized by muscular relaxation, lessened physical activity, dimness of vision, loss of pain and hunger, slowing of respiration and contraction of pupils. Larger doses (15–20 mg.) induce sleep. In some persons, nausea and vomiting are common, and delirium and convulsions may also occur. In still larger doses of morphine, the depression deepens to unconsciousness and may lead to death (B.P.C., 1963, 505; U.S.D., 1955, 864–65; Manske & Holmes, V, 4).

Codeine resembles morphine in its general effects, but is less narcotic, less constipating and almost without euphoric effect. It stimulates not only the spinal cord, but also the lower parts of the brain. Its depressant effect on the higher cerebral centres is weaker than that of morphine and the sedative action upon the respiratory centres is less marked. In small doses, it induces sleep whereas large doses cause restlessness and increased reflex excitability.

Papaverine acts chiefly as a relaxant of involuntary muscles and has no marked narcotic or analgesic action. It relaxes the muscles of the intestinal and biliary tracts, bronchial tree, ureter, and blood vessels including the coronary supply. It has more tendency to slow the heart than either morphine or codeine. Administration of papaverine hydrochloride intravenously is found to produce appreciable increase in cerebral blood flow. Respiration is not profoundly affected (U.S.D., 1955, 349, 969; Henry, 265, 196; Manske & Holmes, IV, 44).

Narcotine, which is the most abundant of the alkaloids after morphine, has only a very mild narcotic action and stands between codeine and thebaine in its convulsant activity. Its depressant effect on involuntary muscles resembles that of papaverine. Narcotine accelerates the respiration and in this respect differs from morphine which acts as a depressant. It has a colchicine-like action on mitosis though much weaker. Thebaine is convulsant rather than narcotic in action. In large doses, it produces in some animals tetanic spasms similar to those of strychnine, and it may paralyze the peripheral motor nerves. In dogs, it acts as an anti-emetic (Chopra *et al.*, Indian J. med. Res., 1930-31, 18, 35; U.S.D., 1955, 929; Henry, 211, 266; Manske & Holmes, IV, 189).

Narcotoline resembles narcotine in action, but is weaker. Oxynarcotine is stated to have feeble narcotic effects. Narceine preparations have sedative and hypnotic effects, but the base is believed to have little action when pure. Hydrocotarnine produces in lower animals symptoms similar to those caused by narcotine. Laudanosine and laudanine are convulsant poisons, resembling thebaine in action. On the heart and respiration, laudanosine has an action similar to papaverine, but is reported to be less active as a spasmolytic agent (Henry, 211, 198; Nadkarni, I, 910; U.S.D., 1955, 927).

Cryptopine depresses the higher nervous centres, and finally causes spinal paralysis in frogs; in mammals, it produces convulsions. It is said to resemble papaverine in its action on involuntary muscles, but is much milder. Protopine when given parenterally in large doses (18-200 mg./kg.) to experimental animals, induces excitement or convulsions; small doses slow the heart, lower the blood pressure and have a sedative effect. It exerts a marked stimulating action on the uterus, but the effect *in vivo* is of very brief duration (Henry, 305; Manske & Holmes, V, 188).

Neopine is analgesic but is less active than morphine; its convulsant action is also weaker. It is about half as toxic as codeine. Aporeine is believed to have a tetanizing action and its general effects are similar to those of thebaine. Meconidine is also stated to exhibit a slight tetanizing effect (Henry, 265, 276, 259).

✓
USES

Medicinal—Opium is used as narcotic, sedative, anodyne, antispasmodic, hypnotic and sudorific.

Whole opium is much less used nowadays and its pure alkaloids, mainly morphine and codeine, and particularly their salts are preferred. Opium is official in pharmacopoeias of several countries. Indian Pharmacopoeia defines opium as the latex obtained by incision from the unripe capsules of *P. somniferum* Linn., dried or partly dried by heat or spontaneous evaporation, and worked into somewhat irregularly shaped masses (natural opium) or moulded into masses of more uniform size and shape (manipulated opium). It has a strong and characteristic odour and a bitter taste and should contain 49.5% of morphine, calculated as anhydrous morphine. Opium is marketed as cubical pieces (wt., 900 g.), varying from hard and brittle to plastic, internally dark brown, smooth and homogeneous. When opium is prescribed, powdered opium is dispensed; for intestinal use, it is given in aromatic powder of chalk. Opium tincture and camphorated opium tincture are the most generally used in dosage forms; the latter is given in cough. Suppositories of opium with lead are employed to relieve rectal and pelvic pains and an ointment of opium with gall is applied in haemorrhoids. Opium is also employed externally in liniments, and the tincture is added to lotions often with a solution of lead subacetate (Merck Index, 756; Snell & Snell, 509; I.P., 442; U.S.D., 1955, 929; B.P., 1963, 543; B.P.C., 1959, 510-12).

Opium is used in veterinary practice, though for the relief of pain, it is not so reliable as in human medicine. It is used in diarrhoea and dysentery and as a sedative expectorant and antispasmodic. The sedative and hypnotic effects of opium are not well marked in animals except in dogs, in which case the dose must be carefully controlled to avoid vomiting and extreme nausea. In other animals, the drug produces excitement and restlessness which differ in degree according to species (B.V.C., 246, 617; Merck Index, 756).

Opium owes its physiological activity chiefly to the predominant alkaloid morphine, though the presence of minor alkaloids may modify its effects. Narcotine and papaverine relax intestinal muscles in contrast to morphine and codeine which increase their tone; this action contributes to the greater constipating effect of opium as compared with that of morphine. Opium has a more marked diaphoretic action than morphine, but its hypnotic and analgesic effects are less certain. The pure alkaloid has the advantage that it is absorbed more readily, can be given hypodermically and its doses determined with greater accuracy.

(B.P.C., 1963, 545-46; Chopra *et al.*, 169; U.S.D., 1955, 929; Encyclopaedia Britannica, XVI, 810).

Morphine is used to relieve pain, anxiety, and sleeplessness due to pain. In its pain-relieving power, morphine is without a rival. It also reduces all disagreeable sensations apart from skin irritation. It is invaluable in the treatment of biliary or renal colic, severe trauma, internal haemorrhage, myocardial infarction, and congestive heart failure. As a sedative to the respiratory centre, it is of special value in cardiac asthma and whooping cough. It has also been used in diarrhoea and as a diaphoretic, in the form of Dover's powder, in colds, rheumatism and influenza. It is now rarely employed as a hypnotic except when the insomnia is due to pain. Since morphine affects the digestive system and there is a major danger of habit formation, it should be used with discrimination and only in acute cases. It must be used with caution in infants, the old and debilitated. It is generally employed as its sulphate or hydrochloride, both of which are official in Indian Pharmacopoeia. The salts are administered in tablets or as injections. If given in excess, the drug is eliminated by the intestines and kidneys (U.S.D., 1955, 864-66, 869; B.P.C., 1963, 505; I.P., 396-97, 308).

Codeine is used as a mild analgesic and as a respiratory sedative. It is widely used for the relief of irritating cough such as in tuberculosis, and is recommended in insomnia due to incessant coughing. It is useful against the pain of cancer (in all but severe cases) and head trauma. It is also recommended as a sedative in cases of mental disorders. Since codeine addiction is rare, it has a great advantage over morphine. Codeine is sometimes employed to check morphine addiction. Codeine is eliminated by kidneys. It is generally administered as phosphate (official in Indian Pharmacopoeia), in tablets or in linctuses (U.S.D., 1955, 348-50; B.P.C., 1963, 201; I.P., 149; Manske & Holmes, V, 38-40; Snell & Snell, 469; Modi, 580).

Papaverine is used as an antispasmodic, and is given orally or by intravenous injection. It is administered as the hydrochloride (official in Indian Pharmacopoeia). It has been found useful in the treatment of spastic conditions of the stomach and intestines caused by hyperacidity and duodenal ulcers. It is also prescribed in asthma and biliary colic. A 10% solution of its sulphate produced complete anaesthesia of the conjunctiva. Papaverine is also used in the therapy of coronary artery disease, pulmonary and peripheral arterial embolisms and in Raynaud's disease. It is

toxic in doses of 100-200 mg./kg. for various animals (Ginsburg, 1; Manske & Holmes, IV, 45; V, 223; I.P., 450-52; U.S.D., 1955, 969-70).

Narcotine is beneficial in allaying cough and headache. It may be useful in asthma, whooping cough, and spasms of intestine, bile duct and urethra. Narcotine, though formerly used in India for treatment of malaria, is reported to have neither a prophylactic nor curative effect (Chopra *et al.*, *Indian J. med. Res.*, 1930-31, 18, 35; Chopra, 1958, 214-15; Mukerji, *Indian J. Pharm.*, 1955, 17, 202).

Poisoning—Toxic doses of opium or morphine produce sleep, respiratory depression or paralysis, pinpoint pupils, coma and death. Cases of poisoning sometimes with fatal results have occurred when opium or morphine enter the system through an abraded surface or a wound. Symptoms produced by opium or morphine poisoning are very similar except that in the case of morphine about one-tenth of the dose is required and the effects appear more quickly. Unusual symptoms reported in opium poisoning include vomiting, purging, convulsions of a tetanoid character (more frequently in children) and syncope. Fatal dose of the drug varies with individuals. In children, much smaller doses have proved lethal. Fatal period is 8 to 12 hours. Cases of suicide by opium are quite common (U.S.D., 1955, 930; Merck Index, 756; Chopra *et al.*, 175-76; Modi, 581-86).

Opium poisoning is treated by evacuating the stomach by tube or by emetics. The stomach tube is, however, preferable to emetics, as the latter often fail to act because of the effect of the drug upon the vomiting centre. The best chemical antidote is potassium permanganate (dose 300 mg.). Tannic acid may be used as a partial antidote, but it is less satisfactory as the tannate of morphine is slowly absorbable; it is well to follow it with a saline cathartic (U.S.D., 1955, 930; Chopra *et al.*, 176).

Symptoms of codeine poisoning in man are nausea, vomiting, abdominal pain, contraction of pupils and increased pulse rate. Death seldom occurs. Treatment of codeine poisoning is on the same lines as that of morphine poisoning. Codeine is reported to cause contact dermatitis. Narcotine is much less poisonous than morphine or codeine and produces toxicity only in very large doses; 2-3 g. can be taken without any ill effects (U.S.D., 1955, 350; Modi, 580; Chopra *et al.*, *Indian J. med. Res.*, 1930-31, 18, 35).

Opium addiction—The habit of taking opium or morphine has been prevalent for a long time in India, but is now fast dwindling. Opium and its derivatives

are consumed in three ways, viz. orally, by smoking and by injection, the first being the commonest.

The habit of eating opium is acquired as it produces a sense of euphoria and in the belief that it has a remarkable power as an aphrodisiac. Ordinarily crude opium is used, but, sometimes its solution or decoction (*Kasoomba*) is drunk. Once the habit is formed, it is difficult to give it up. The addict has to take more of the drug to combat the feelings of lethargy and mental depression, as the symptoms of the first dose wear off. Daily intakes of 1-4 g. of opium have been recorded. Its abuse for a prolonged period leads to derangement of appetite and digestion, disturbance of sleep, vomiting, emaciation, impotence, neurasthenic condition, mental perversion of morality, dementia, mania and premature old age. These symptoms are more evident in morphine eaters than in opium eaters, and are known as morphinism or morphinomania (Modi, 589-90; Chopra *et al.*, 177-78; Manske & Holmes, V, 33).

Opium is smoked in India in the form of Madak, Chandu or opium dross. *Madak* is prepared by impregnating coarsely powdered leaves of *babul* (*Acacia arabica*) or guava (*Psidium guajava* Linn.) or husk of *kotu* (*Setaria glauca* Beauv.) in concentrated aqueous extract of opium and rolling the impregnated mass into small balls. *Chandu* is a dark brown concentrated aqueous extract of opium containing small quantities of carbonaceous residues (*Inchi*) from opium smoking pipes; its morphine content is c. 8%. The ash from smoking *chandu* is known as opium dross. Excessive opium smoking leads to loss of appetite, a leaden pallor of the skin and extreme leanness of the body, resulting in the addict losing all inclination for exertion. Smoking opium is sometimes adulterated with powdered poppy capsules [Modi, 589; Chopra & Chopra, *Bull. Narcotics*, 1955, 7(3-4), 1; Chakravarti & Mehrotra, *J. Indian chem. Soc., industr. Edn.*, 1943, 6, 52; Kanny Lall Dey, 225; Wallis, 438; B.P.C., 1963, 545; Chopra, *Curr. Sci.*, 1939, 8, 593].

The addiction of opium or morphine through hypodermic injections is prevalent in Europe and the U.S.A. and is now spreading in India also (Chopra *et al.*, 178).

Opium or morphine addiction may be treated either by the 'Sudden Method' or the 'Slow Method'. Sudden deprivation of opium or morphine produces in addicts various physiological disturbances and this method is recommended only for children. By the slow method, it takes three to six weeks to effect a cure, the decrease in dosage of the drug being carried

out very gradually at first and then more rapidly. Other treatments for addiction include insulin injections or periodical injections of a fluid from a blister raised on the thigh or abdomen of the addict himself (Modi, 590; Chopra *et al.*, 180-82).

PRODUCTION AND TRADE

India has been producing opium for many centuries, and is at present the largest source of supply of raw opium to the world; next to India, Turkey and U.S.S.R. are the main opium producing countries (Table 6). Large quantities of opium used to be produced in India during the later half of the last century, the bulk of which was exported to China. With the cessation of exports to China and with increased international control on opium, the production of opium has now declined to the quantity needed for medicinal and scientific purposes.

Opium is exported for scientific and medicinal purposes chiefly to U.K., U.S.A. and France (Table 7). The supply is made subject to the receipt of an import certificate issued under the Geneva Convention of 1925 by the Chief Narcotics Officer or any other officer authorized on behalf of the importing country and accepted by the Government of India, in the Ministry of Finance (Revenue Division). Small quantities of opium are also imported into India (Vardhan, loc. cit.).

The trade and prices of opium and opium alkaloids are entirely controlled by the Government. Excise opium is supplied to State Governments on 'no loss no profit' basis. It is sold by licensed

TABLE 6—WORLD PRODUCTION OF RAW OPIUM*

(in thousand kg.)

	1957	1958	1959	1960	1961	1962
India (a)	485	657	763	914	912	971
Turkey	45	162	168	365	172	311
U.S.S.R.	147	93	132	169	120	148
Yugoslavia	15	18	25	40	35	4
Pakistan	5	5	5	6	11	8
Bulgaria	2	2	1	1	1	(b)
Japan	1	2	3	3	4	2
TOTAL	700(c)	939	1,097	1,498	1,255	1,444

* Rep. Permanent Central Opium Bd, United Nations, Geneva, 1961, No. E/OB/17 and 1963, No. E/OB/19.

(a) Quantities at 70° consistency; (b) Quantity less than 1,000 kg.; (c) Excluding 12,500 kg. produced in Afghanistan.

TABLE 7—EXPORTS OF OPIUM*
(in thousand kg.)

	U.K.	U.S.A.	France	Italy	Other countries	Total
1951-52	75	69	11	..	1	156
1952-53	71	24	25	..	..	120
1953-54	149	87	20	1	3	260
1954-55	146	29	25	9	5	214
1955-56	132	91	10	9	6	248
1956-57	183	43	50	15	39	330
1957-58	137	129	60	18	102	446
1958-59	173	130	71	11	142 ^a	527
1959-60	165	147	57	11	155 ^b	535
1960-61	245	181	71	2	103 ^c	602
1961-62	186	191	81	26	100	584
1962-63	142	68	20	7	36	273

* Information from Government Opium & Alkaloid Works, Ghazipur. Years refer to Opium Year, Oct.-Sept.

^a Includes exports to U.S.S.R., 49,786; Argentina, 11,176; W. Germany, 50,802; Japan, 24,385; and Belgium, 5,080 kg.

^b Includes exports to U.S.S.R., 37,884; Argentina, 15,266; W. Germany, 66,736; Japan, 30,942; and Belgium, 4,927 kg.

^c Includes exports to U.S.S.R., 57,852; Argentina, 3,844; W. Germany, 19,222; Japan, 14,818; and Belgium, 7,465 kg.

dealers and is converted by the registered addicts themselves into prepared opium. After March, 1959, issue of opium to opium smokers has been made from the Government depots. The selling price of export opium is fixed by the Government, taking into account the cost of production, the demand for opium in international market and the price offered by other opium producing countries [Vardhan, loc. cit.; 54th Rep., Estimates Comm., 1958-59, Minist. Finance (Dep. Revenue), Narcotics Dep., Govt. India, 16].

POPPY SEEDS AND CAPSULES

Poppy is cultivated also for its seeds. In Europe, var. *nigrum* which has slate coloured to blue coloured seeds and known as Maw Seeds, is exclusively cultivated for this purpose. In India, var. *album*, with white seeds, has been cultivated for many years for the production of seeds under licence in Dehra Dun and Tehri Garhwal districts of U.P., and in Jullundur, Kapurthala, Hoshiarpur and Patiala districts of Punjab. The continuance of cultivation of

poppy for poppy heads and seeds was reviewed by the All India Narcotics Conference, 1956, and on their recommendation, Punjab Government banned the cultivation of opium poppy for poppy heads, with effect from March 1958. The U.P. Government was, however, allowed to continue cultivation of poppy for poppy heads for a maximum period of four years by which time it was expected that necessary development measures would be taken to enable the cultivators to raise alternative crops in lieu of opium poppy. In India, best seeds are obtained when the capsules have not been incised for extraction of opium. The crop is reported to yield 220-275 kg. of seeds per hectare (200-250 lb./acre) [54th Rep., Estimates Comm., 1958-59, Minist. Finance (Dep. Revenue), Narcotics Dep., Govt. India, 8-9; Roberts & Kartar Singh, 500; Mollison, III, 247].

Poppy seeds (wt., 0.25-0.50 g./1,000) are devoid of narcotic properties and are utilized as food and as a source of fatty oil. They are considered nutritive and are used in breads, curries, sweets and confectionery. Seeds are deinulcent and are used in the form of emulsion as an emollient and as a specific against obstinate constipation and in catarrh of the bladder. The white seeds are sometimes used in pharmaceuticals. Poppy seeds or seed meal also find use in the production of lecithin (yield, 0.67-0.91%) [Bull. Narcotics, 1953, 5(3), 9; Chopra, et al., 174; Steinmetz, II, 330; Snell & Snell, 429; Chem. Abstr., 1951, 45, 1304].

Analysis of seeds from five types of Indian poppy gave the following ranges of values: moisture, 4.3-5.2%; protein, 22.3-24.4%; ether extr., 46.5-49.1%; N-free extr., 11.7-14.3%; crude fibre, 4.8-5.8%; ash, 5.6-6.0%; calcium, 1.03-1.45%; and phosphorus, 0.79-0.89%; iron, 8.5-11.1 mg./100 g.; thiamine, 740-1,181; riboflavin, 756-1,203; and nicotinic acid, 800-1,280 µg./100 g.; carotene is absent. Minor minerals in the seeds include iodine (6 µg./kg.), manganese (29 mg./kg.), copper (22.9 mg./kg.), magnesium (15.6 g./kg.), sodium (0.3 g./kg.), potassium (5.25 g./kg.), and zinc (130 mg./kg.). The seeds also contain lecithin (2.80%), oxalic acid (1.62%), pentosans (3.0-3.6%), traces of narcotine and an amorphous alkaloid, and the enzymes diastase, emulsin, lipase and nuclease (Satyanarayana et al., J. sci. industr. Res., 1956, 15C, 211; Iodine Content of Foods, 124; Winton & Winton, I, 434; Chem. Abstr., 1957, 51, 17616; Roychowdhury et al., J. Instn Chem. India, 1962, 34, 89; Ghatak & Krishna Murti, J. sci. industr. Res., 1955, 14A, 285; Wehmer, I, 382).

The seeds have a high protein content, the major component being a globulin which accounts for 55% of the total nitrogen. The amino acid make-up of the globulin is similar to that of the whole seed protein, and is as follows (g./16 g. N): arginine, 10.4; histidine, 2.9; lysine, 2.5; tyrosine, 4.7; tryptophan, 2.0; phenylalanine, 4.1; cystine, 2.0; methionine, 2.3; threonine, 4.2; and valine, 7.1. The proteins are deficient in lysine and methionine. At 10% level of intake, they have a biological value of 57.9% and a digestibility coefficient of 81% (Satyanarayana *et al.*, loc. cit.; Satyanarayana, *Bull. cent. Ed. technol. Res. Inst., Mysore*, 1955-56, **5**, 360; Kuppuswamy *et al.*, 92).

Poppy seed oil—Poppy seeds contain up to 50% of an edible oil which is extracted by either cold or hot expression. The oil is odourless and possesses a pleasant almond-like taste. In India, the oil is generally extracted by cold-pressing the seed in small presses in homes or small establishments (oil yield, c. 20%). Raw cold-pressed oil is pale to golden yellow in colour and is edible without refining; it does not develop rancidity easily. Hot-pressed oil is largely used in soap making. It may be rendered edible by refining. The oil yield from black and white seed is about the same, but the former is more commonly used for expression of the oil because of its easier cultivation. However, white seeds are reported to yield the finest oil. Seeds from the capsules which have not been scarified for opium give a higher yield of oil than from those scarified (Eckey, 447-48; U.S.D., 1955, 923; Williams, K. A., 288; Handbook of Commercial Information for India, 1937, 244; Jamieson, 292).

Poppy seed oil has the following ranges of constants: sp. gr. $_{25}^{13}$, 0.924-0.927; 1.467-1.470; iod. val., 132-142; sap. val., 188-196; acid val., 3-13; hydroxyl val., 21; thiocyanogen val., 77.5; solid. p., -15° to -20°; titre, 15-19°; viscosity at 16°, 35.1 cp.; and unsapon. matter, 0.4-1.2%. A sample of oil (iod. val., 137) obtained from seeds grown in India had the following fatty acid composition: palmitic, 11.0; stearic, 4.2; arachidic, 0.4; oleic, 11.4; and linoleic, 73.0%. Its glyceride composition was as follows: disaturated-linoleins, 1.2; saturated-oleo-linoleins, 8.9; saturated-dilinoleins, 37.0; oleo-dilinoleins, 32.2; and trilinolein, 20.7% mol. Presence of a small amount of linolenic acid is reported in some samples of oil. The unsaponifiable matter contains phytosterol, tocopherol (44 mg./100 g. of oil) and squalene (13 mg./100 g. of oil) (Eckey, 449; Bridges

et al., *J. Oil Col. Chem. Ass.*, 1951, **34**, 354; Wehmer, I, 382; Deuel, I, 798; Dickhart, *Amer. J. Pharm.*, 1955, **127**, 359).

Poppy seed oil is widely used for culinary purposes. It is free from narcotic properties and is used mixed with olive oil, or as a salad oil. It has a high digestibility coefficient of c. 96% at a daily intake of 50 g. On hydrogenation, it yields a product similar to hydrogenated groundnut oil in stability and consistency. The hydrogenated oil may also be useful for industrial purposes (U.S.D., 1955, 923; Deuel, II, 216; Williams, K.A., 289; Basu & Chakrabarty, *J. sci. industr. Res.*, 1960, **19B**, 227).

Poppy seed oil is a non-yellowing drying oil forming a hard and lustrous film. The oil is rendered colourless by exposure to the sun. It dries much slower and more uniformly than linseed oil. Modified oils, with good drying properties for use in paints or varnishes, can be prepared by heating the raw oil for 5-12 hours at 150-180°, in the presence of catalysts. Blown poppy seed oil on dehydration and treatment with cobalt forms films resistant to boiling water and in this respect equivalent to those formed by dehydrated castor oil. Poppy seed oil is used in the production of artists' paints; for this purpose sun-bleached oil from the first cold pressings of the seed is preferred. The oil is useful in the preparation of linoleic acid, soft soaps, ointments and emulsions, and compositions for skin care. The oil finds use also as an illuminant. It is used against diarrhoea, dysentery and scalds. Lower grades are used for lubrication. Poppy seed oil is used in Europe as a substitute and adulterant of olive oil which it resembles very much (Eckey, 448; Ghose, *Indian For.*, 1939, **65**, 742; Aggarwal *et al.*, *Indian Pat.*, No. 42,885, 1951; Steinmetz, II, 330; Hilditch, 1943, 128, 487; Chatfield, 74, 269; Williams, K. A., 289; U.S.D., 1955, 923; Hoppe, 637; *Chem. Abstr.*, 1950, **44**, 5551).

Poppy seed cake—The cake or the meal left after extraction of the oil from the seeds is sweet and nutritious and is eaten by poor people. It is readily consumed by cattle and sheep, and may be fed alone or preferably mixed with other feeds. Excessive feeding of the cake (over 1 kg./day) to dairy cattle may result in decrease of the fat content of milk and in soft fat. The cake is not recommended for young or breeding animals. Analysis of the cake gave the following values: moisture, 10.8; crude protein, 36.6; N-free extr., 20.7; ether extr., 7.9; fibre, 11.6; mineral matter, 12.4; dig. protein, 30.4; and total dig. nutrients, 62.3%; nutritive ratio, 1. The cake may

PAPAVER

also be used as a manure (Ghose, loc. cit. ; Altschul, 589-90 ; Morrison, 500, 1060).

The seed cake may sometimes prove toxic to cattle owing to the presence of alkaloids arising from contamination of the seed with particles of the capsule. This results in marked gastro-enteritis, nervous excitement, lack of appetite and colicky pains. Lactation may cease and cattle lose weight progressively ; few fatal cases have been reported (Forsyth, *Bull. Minist. Agric., Lond.*, No. 161, 1954, 25 ; Altschul, 589).

Capsules—The capsules contain the same constituents as opium but in much smaller quantities. The total alkaloid content of the unlanced capsules from Indian sources was found to be 0.4-0.6% and that of the lanced capsules 0.15-0.22%. The concentration of morphine in the capsules shows large variations ; the value ranged from 0.18 to 0.90% in samples of capsules from several countries. The capsules account for c. 70% of the total morphine of the plant. The morphine in the capsules decreases rapidly on storage. Narcotoline content of the capsules is reported to be 0.1-0.2% (Hoppe, 636, 639 ; Chopra & Ghose, *Indian J. med. Res.*, 1931-32, 19, 415 ; Henry, 176 ; *J. Pharm., Lond.*, 1952, 4, 337 ; Brekke *et al.*, *J. agric. Fd Chem.*, 1958, 6, 927 ; *Chem. Abstr.*, 1956, 50, 13371).

The carbohydrate components reported in the capsules include glucose, fructose, sucrose, sedoheptulose, mannoheptulose, and a complex polysaccharide comprising arabinose, xylose, rhamnose, glucose, galactose, uronic acid and an unidentified component (Ottestad *et al.*, *J. Pharm., Lond.*, 1959, 11, 689).

In U.S.A., mature poppy capsules have been processed to yield a liquor which can be used as a substitute for opium in the production of morphine. In Europe, instances of poisoning have been reported when cattle have eaten unripe capsules of the plant (Brekke *et al.*, loc. cit. ; Muenscher, 96).

An infusion of the capsules is used as a soothing application for bruises, inflammatory swellings and sometimes for painful conjunctivitis and inflammation of the ear. A hot decoction of capsules is applied as an anodyne. Capsules are used also in the form of syrup or extract as a sedative against irritant coughing and sleeplessness. In India, an intoxicating liquor is prepared by heating the capsules with jaggery and water (I.P.C., 199 ; Steinmetz, II, 329 ; Chopra, 1958, 203).

Poppy straw (dry, unlanced empty capsules, having a stem of c. 7.5 cm.) has been made use of in Europe and other places, where the plant is cultivated

primarily for its seed and oil, as a source of morphine and narcotine. The two alkaloids are obtained in a yield of 0.08 and 0.009% respectively. Poppy straw and heads have also been processed to yield concentrated alkaloidal extracts, such as 'Optopon' (morphine, 20-22% ; other opium alkaloids, 16-18%) which can be used directly as a pharmaceutical. Poppy straw has been tried for the manufacture of handmade boards (Henry, 176 ; *Chem. Abstr.*, 1938, 32, 8074 ; 1957, 51, 9090 ; 1951, 45, 9813 ; 1950, 44, 4245).

OTHER USES OF OPIUM POPPY

Poppy leaves were at one time official in French Pharmacopoeia. They contain morphine (0.03-0.2%), narcotine, papaverine and codeine in small quantities. Presence of sanguinarine was recently reported in the leaves ; the alkaloid also occurs in the root and stem but possibly not in opium. The maximum concentration of morphine in the leaves is at the time of development of flower buds. The leaves are smeared as anodyne (Hoppe, 635, 639 ; Hakim *et al.*, *Nature, Lond.*, 1961, 189, 198).

Young poppy plant is sometimes eaten like lettuce. It is grown as a pot-herb in Iran and is also fed to cattle. Leaves and petals have been used for packing opium (Hakim *et al.*, loc. cit.).

The poppy plant has been tried in the production of paper pulp. Kraft pulping gave pulps having good strength properties and useful for the manufacture of wrapping papers, bags and other grades requiring an improved formation (*Chem. Abstr.*, 1953, 47, 12809).

The red poppy flowers are used in medicine for making a syrup. The red and lilac flowers contain a colouring matter and are suitable for use as an indicator (Snell & Snell, 428 ; *Chem. Abstr.*, 1930, 24, 310). ✓

Papaya or Papaw—*see* *Carica*

Paper, Awobana—*see* *Commelina*

Paper Birch—*see* *Betula*

Paper-Mulberry—*see* *Broussonetia*

Paper, Nepal—*see* *Daphne, Edgeworthia*

Paprika—*see* *Capsicum*

Paragonite—*see* *Mica*

Para Grass—*see* *Brachiaria*

Paraguay Tea—*see* *Ilex*

PARAMERIA Benth. (*Apocynaceae*)

A genus of evergreen climbing shrubs distributed in Indo-Malaysian region and S. China. Three species occur in India.

***P. barbata** K. Schum. syn. *P. glandulifera* Benth.

D.E.P., VI (1), 109; IV, 361; C.P., 658; Fl. Br. Ind., III, 660.

A large scandent shrub found in the interior and littoral forests in Andaman Islands. Leaves elliptic-oblong or obovate-lanceolate, coriaceous; flowers in small paniculate cymes, white, fragrant; follicles slender, moniliform; seeds with long silky hairs.

The latex from *P. barbata* on coagulation yields a light brown rubber of good quality, but not commercially exploitable. The latex is collected by a somewhat destructive method of cutting the stems into short lengths and allowing the milky juice to drain into vessels containing hot water; on agitation the latex coagulates. Analysis of the rubber (from Andamans) gave the following values: caoutchouc, 91.6; resin, 5.8; nitrogenous matter, 1.9; and ash, 0.7%. In Malaya, Java and Philippines, a decoction of the bark is applied to wounds and also taken in dysentery. A chemical examination, however, showed the bark to be physiologically inert. An infusion of leaves and flowers is reported to be administered as an emmenagogue (*Bull. imp. Inst., Lond.*, 1907, 5, 14; Burkill, II, 1661-62; Quisumbing, 736).

P. pedunculosa Benth. is a slender climber with elliptic leaves and paniculate cymes of pinkish flowers, found in Manipur and hills of Assam. A sample of the latex from the plant on solidifying yielded a pinkish white curdy substance, which did not possess the physical qualities of rubber and on drying formed a friable powder. Analysis of the dried material showed: caoutchouc, 10.7; resin, 88.5; and insoluble matter, 0.8% (*Bull. imp. Inst., Lond.*, 1905, 3, 230).

P. polyneura Hook. f. (ASSAM—*Mikirtengalata*) is a slender climbing shrub with elliptic-oblong or obovate leaves and paniculate cymes of small flowers, found in Darrang in Assam. It yields rubber of good quality resembling that from *P. barbata*. It is also used medicinally in Malaya like the latter species (Burkill, II, 1662).

* This is considered by some authors as a synonym of *P. laevigata* (Juss.) Moldenke (Bakhuizen van den Brink, *Blumea*, 1947-52, 6, 387).

PARAMIGNYA Wight (*Rutaceae*)

D.E.P., VI (1), 110; Fl. Br. Ind., I, 509; Swingle in Webber & Batchelor, I, 253; Kirt. & Basu, Pl. 195 & 196.

A genus of erect or climbing shrubs distributed in the Indo-Malaysian region. Seven or eight species occur in India.

P. monophylla Wight (MAR.—*Kurwa-wagutti*; TAM.—*Katillinsecham*; KAN.—*Kadukanji*, *kan-nimbe*, *kankanchibally*) is an evergreen thorny climber with unifoliolate, oblong or elliptic leaves, white fragrant flowers and ovoid or obovoid yellow fruits found in the eastern Himalayas, Khasi and Aka hills, Orissa, Andhra Pradesh and the evergreen forests of the western ghats up to an altitude of 1,800 m. The root is rich in calcium oxalate crystals. It is used as an alterative and diuretic. It is given also to cattle in haematuria and other bloody fluxes from the abdomen (Chandrasena, 60).

The triquetrous fruits of *P. angulata* Kurz syn. *P. longispina* Hook. f. (BENG.—*Ban nimbu*), a thorny lime-like bush, found in Sundarbans, are used in colic. *P. scandens* Craib syn. *P. griffithii* Hook. f. (Fl. Br. Ind.) in part, found in Assam and Orissa bears very acid fruits [Kirt. & Basu, I, 481-82; Krishna & Badhwar, *J. sci. industr. Res.*, 1948, 7(6), suppl., 105].

Para Palm — see **Euterpe**

Para Rubber Tree — see **Hevea**

PARASITIC WORMS

Parasitic worms or Helminths are obligatory parasites found on or in the body of other organisms (hosts), viz. human beings, domestic pets, livestock, plants, insects, etc., on whom they depend for their nourishment and protection. Forms that live superficially on the body of the hosts are ectoparasites and those that occur either in a free state or in intimate association with the intestinal wall or other tissues within the body of the hosts are known as endoparasites. Helminth parasites include the flat leaf-like flukes, the long ribbon-like tapeworms and the elongated roundworms.

Helminths and diseases caused by them were known to the people of ancient India. Charaka (c. 500 B.C.) referred to the origin and occurrence of worms and Susruta (c. 200 B.C.) recorded a detailed account of twenty different kinds of worms under Krimi-roga-pratisedha; accounts of worm parasites are also found in Kashyap samhita and Madhya nidhana (A.D. 700-800).

PARASITIC WORMS

Helminth parasites are well adapted to their parasitic modes of life. They develop special adhesive organs, such as suckers and hooks, by which they attach themselves firmly to their hosts. They are generally devoid of organs of locomotion and of sight during their parasitic existence; but these are acquired during their larval life. In certain intestinal parasites digestive organs are also lost, as the digested food is directly assimilated.

Various symptoms, such as non-inclination for food, nausea, vomiting, itching of nose, grinding of teeth during sleep and the like are caused by the presence of these worms in the human body. Generally the infection may result from eating contaminated and improperly cooked food or raw vegetables, or it may be transmitted through domestic pets. Sometimes larval forms of the parasites penetrate through the skin, either during bathing in contaminated water or by the bite of intermediary hosts such as insects. Insanitary environments also play an important role in the spread of helminth infection.

Helminth parasites remain parasitic in almost every part of the body of the host, causing diseases of the organs in which they occur. They are known after the organs or places of their occurrence, such as liver-flukes, blood-flukes, seatworms, eyeworms, lung-worms, etc. These parasites induce pathogenic changes in the host by creating diseased condition of the organs. Even the forms that are apparently harmless exercise their baneful influence in lowering the vitality and general health of the host.

The number of helminth species found in man alone is to the tune of 120, many of which are associated with diseases. As many as 70 species of parasites are known to be present in horses, nearly 100 in dogs, about 100 in cattle, 54 in pigs and 93 in fowls. A few nematodes are also reported to be parasitic on insects. The damage these parasites cause to livestock is considerable.

Parasitic worms cause also serious loss to agricultural and horticultural crops. Eelworms are responsible for causing various diseases of important crops, such as potato, clover, sugarcane, citrus, banana, coconut, etc.; these worms attack ornamental plants also. Some larval cestodes act as nuclei in pearl formation in oysters (Encyclopaedia Britannica, XVII, 270B; Bhalerao, *Sci. Monogr. Indian Coun. agric. Res.*, No. 6, 1935; Cameron, *Brit. med. J.*, 1934, 1110; Chandler, A.C., 199-372; Thapar, *Lucknow Univ. Stud.*, No. 3, 1936, 1; *J. Banaras Hindu*

Univ., 1941-42, 6, 23; *Curr. Sci.*, 1944, 13, 274; *Indian J. vet. Sci.*, 1956, 26, 211; Reese, 33-47).

Flukes (Phylum *Platyhelminthes*, class *Trematoda*)

Flukes are either ectoparasitic, with a simple life-cycle (*Monogenea*), developing directly in or on a single host or endoparasitic, having a complicated life-cycle (*Digenea*), with a series of larval forms different from the parent undergoing development in intermediate hosts. *Monogenea* flukes are mostly ectoparasitic on the skin and gills of fishes and sometimes on crustaceans. *Digenea* flukes are found in vertebrates in various parts of their bodies except the nervous, skeletal and reproductive systems. Some of the more important forms of this sub-class which are parasitic in man and domestic animals belong to the genera *Fasciola* Linn., *Amphistomata* (Rudolphi), *Dicrocoelium* Dujardin, *Opisthorchis* Blanchard, *Schistosoma* Weinland, etc.

LIVER-FLUKE [*Fasciola gigantica* Cobbold (*Fasciolidae*)] is extremely common in India and is a serious menace to livestock. The adult fluke is characterized by the comparatively large size of its body with a small triangular projection or the head papilla at its broad anterior end, an anterior oral sucker and a ventral sucker both of which are present near the anterior end. It lives in the liver and bile ducts of the infected animals and causes mechanical obstruction of the biliary passages by irritation of biliary epithelium, resulting in hypertrophy and deposition of sclerified connective tissue in concentric rings round the ducts and destruction of blood corpuscles, causing eosinophilia, finally leading to cirrhosis of the liver or liver-rot. A large number of eggs produced by a single fluke are passed out with the faeces of the host. The eggs, under suitable conditions, hatch out into free swimming ciliated larvae (Miracidia), which are short-lived, but if a miracidium happens to meet the snail *Limnaea acuminata* Linn., it penetrates into its mantle cavity and undergoes a complete metamorphosis within six days to form a sporocyst, which contains inside its body a number of rediae at different stages of development. When fully formed these rediae are liberated and in about 20 days of the infection they begin to produce the next generation, the cercariae, which when fully mature get out of the snail host. A mature cercaria resembles the adult fluke, but has a tail in addition. After its emergence from the snail it fixes itself to a blade of grass or some other vegetation. Soon after the tail is lost and a cyst is developed by the formation of a double

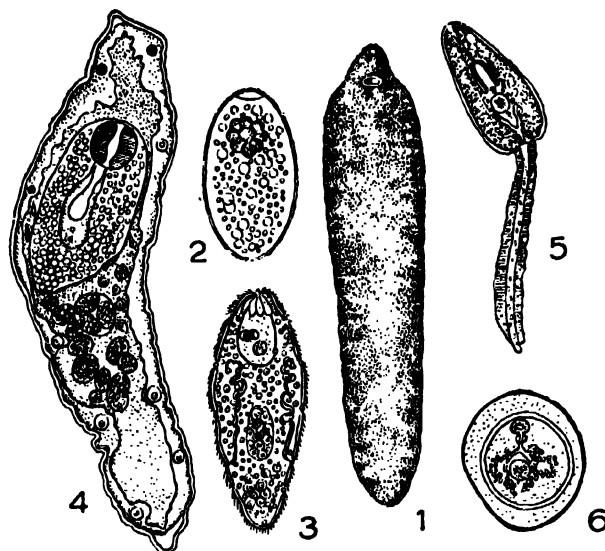


FIG. 101—LIVER-FLUKE (*FASCIOLA GIGANTICA*)
STAGES IN LIFE-CYCLE

1. Adult fluke ($\times 2$) ; 2. Egg ($\times 140$) ; 3. Miracidium larva ($\times 150$) ;
4. Sporocyst with rediae ($\times 36$) ; 5. Cercaria ($\times 62$) ; 6. Metacercaria ($\times 62$)

covering round the cercaria. It is now known as metacercaria. These cysts, containing metacercariae, are eaten by the final host along with the vegetation : cyst wall is dissolved by the digestive juices of the host and the young flukes are liberated. They migrate along the bile duct into the liver tissues of the host and grow into mature flukes.

Liquid extract of the male fern (*Dryopteris filix-mas* Schott) and Danistol, a proprietary preparation of male fern, are used against the fluke infection. The cheapest remedy is carbon tetrachloride, which is quite effective, but should be used with caution. Destruction of snails, the intermediary hosts, by the use of copper sulphate, and filling of wet and marshy areas, minimize the chances of further infection. Introduction of ducks into streams helps to keep down snail populations.

Fasciolopsis buski (Lankester), a related large fluke of the same family, found generally in pigs and wild boars, has also been reported from the duodenum and large intestines of inhabitants of W. Bengal and Assam. Although closely resembling the liver-fluke in structure and life-history, it is easily differentiated from the latter by the absence of head papilla. The intermediate snail host is a species of either *Planorbis* Geoffroy or *Segmentina* Fleming and the metacercariae remain encysted on water-calthrop and

singhara-nut (*Trapa* spp.) or water-nut (*Eleocharis tuberosa* Schult.). When the nuts are eaten raw, after peeling off the skin with the teeth, the cysts of the flukes are incidentally taken into the mouth from where they find their way into the intestines and grow into adulthood. This fluke causes inflammation at the seat of attachment and is associated with diarrhoea in early stages of infection. In acute cases it forms abscesses and ulcers. Carbon tetrachloride, in suitable doses, is used as a therapeutic agent. Human infections can be prevented by cooking or boiling the nuts before use.

AMPHISTOMES (*Amphistomatidae*) *Amphistomata* (Rudolphi) is one of the largest genus of trematodes and a number of species occur in domestic and wild ruminants and equines. Two genera are reported from man, viz. *Gastrodiscoides* Leiper and *Watsonius* Stiles & Goldberger ; the former is also reported from pigs. Amphistomes are characterized by the possession of a large ventral sucker situated at the extreme posterior end of the body ; the oral sucker is small and very often produced into two postero-lateral pouches. The life-history is similar to that of the liver-fluke, metacercariae encysting on vegetation. The usual symptoms of the occurrence of these parasites in the intestines are diarrhoea followed by an inflammation at the seat of attachment. The presence of young amphistomes in sheep and goats give rise to the disease commonly known as *bisi* or *pittoo*, which is very common in Uttar Pradesh and Bihar, where, in extreme cases, it develops into lumbar paralysis, resulting in death of the host. Carbon tetrachloride, administered under expert advice, is sometimes useful.

The species belonging to the genera *Paramphistomum* Fischhoeder, *Cotylophoron* Stiles & Goldberger and *Olveria* Thapar & Sinha are parasites of domestic ruminants, and those of *Gastrodiscus* Cobbold are generally parasites of equines.

Dicrocoelium dendriticum (Rudolphi) (*Dicrocoeliidae*) is a lancet-shaped fluke infesting the liver of cattle, sheep and goats ; but in India, it has been reported from sheep and goats only. The oral sucker is slightly smaller than the ventral sucker. Eggs are small and operculated, each containing a miracidium without eye-spots. They are ingested by the land snail, *Macrochlamys cassida* Godwin-Austen, and develop into cercariae, which are introduced into the final host along with the molluscan host, or as slimy cysts attached to the blades of grass. With the help of their stylets the cercariae penetrate the gut wall

PARASITIC WORMS

and enter the blood stream. Finally they settle in the tissues of the liver and assume adulthood in two months' time. The presence of these worms causes obstruction in the biliary tracts, leading to the hypertrophy of their epithelium, and ultimately to the atrophy of liver cells, resulting in cirrhosis and development of streaks in connective tissue. The infection usually proves fatal.

Eurytrema pancreaticum (Janson), an allied form of the same family, is a common parasite of cattle and pigs, occurring in their pancreatic ducts. It differs from the genus *Dicrocoelium* Dujardin in being broader and stouter and in having the oral sucker larger than the ventral sucker. It causes eurytremiasis in cattle and other herbivores, hypertrophy of the epithelium and wall of the duct in pigs, and may be one of the factors responsible for bovine haematuria. The life-cycle of the fluke is unknown.

Opisthorchis sinensis (Cobbold) (*Opisthorchiidae*) is a common fluke of man in the East and has been reported from W. Bengal. It is slender and transparent, with ventral sucker smaller than the oral sucker and situated in the first quarter of the body. The eggs are small and operculated and develop into miracidia with eye-spots. Miracidia develop in the body of snails of the genera *Bithynia* Leach and *Parafossarulus* Annandale & Prashad. The cercariae, which bear eye-spots, after liberation from the snail, find their way into freshwater fish of the family *Cyprinidae* in whose skin or subdermal tissues they encyst as metacercariae. When the infected fish is eaten in improperly cooked condition, the metacercariae are liberated in the gut of the final host and migrate into the liver where they gradually develop into adults. The symptoms produced by the parasite are similar to those produced by the liver-fluke. Sodium antimony tartrate given intravenously reduces the number of flukes. Penta- and hexamethyl rosaniline given orally or intravenously kills the worms. Infection can be prevented by thorough cooking of the fish intended for human consumption.

Other related species are *O. felinus* (Rivolta), Siberian liver-fluke, found in the liver of cats, dogs, pigs and man; *O. viverrini* (Boirier) found in Siam in civet cat and sometimes in man; and *O. noverca* Braun, the Indian liver-fluke, found very commonly in the pye-dogs and also in man.

BLOOD-FLUKES (*Schistosomatidae*) are elongate, unisexual, dimorphic parasites of the blood vessels of vertebrates. Suckers are poorly developed. The egg is provided with a terminal spine by which it can pierce

through the wall of the blood vessels and escape into the lumen of the urinary bladder to be passed out with urine. Mature miracidia develop directly into cercariae in the hepatic sinuses of snail hosts and are discharged in water in six weeks' time, where they may be able to infect the final host within 48 hours or so by penetrating through its skin. Infection is also possible by drinking water containing the cercariae which pass into the gut and work their way into the blood circulation and develop into adulthood. The period of incubation from cercaria to the adult worm is about one month.

Three species of blood-flukes are known to occur in man, viz. *Schistosoma haematobium* (Bilharz), *S. mansoni* Sambon and *S. japonicum* Katsurada. Of these *S. haematobium* is the causative organism of vesical schistosomiasis, while the other two species cause intestinal schistosomiasis. None of the species was recorded from India till 1950, when *S. japonicum*, a species found in Japan, China and the Philippines, causing the Katayama disease, was reported from Maharashtra. The symptoms of the infection are ascites, cachexia, bronchial trouble and urticarial rashes over the body, and the disease is confirmed by the presence of eggs in urine coloured with blood.

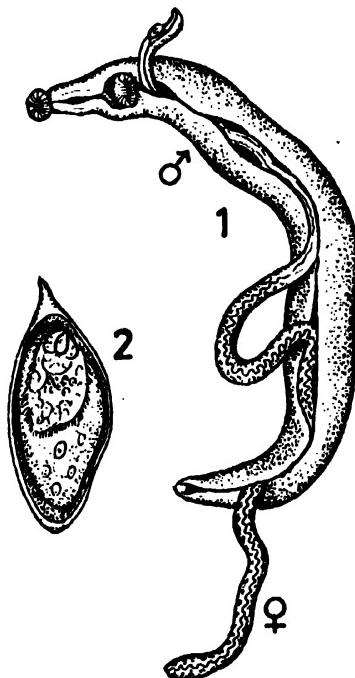


FIG. 102—BLOOD-FLUKE (*SCHISTOSOMA HAEMATOBUIUM*)

1. Adult male and female ($\times 12$) ; 2. Egg with terminal spine ($\times 200$)

S. bovis (Sonsino) is found in the portal veins of sheep and oxen in India. The cercariae give rise to intestinal schistosomiasis with hepatic cirrhosis. Emetine injections are given for treatment. *S. spindale* Montgomery is a parasite of *Bos indicus* Linn. and is also reported from domestic cattle in India. It is distinguished by its very long unilateral spindle-shaped eggs with terminal spines which are voided in faeces. The cercariae cause marked thrombosis of the portal vessels and periportal cirrhosis. *S. nasalis* Datta is reported from Assam, W. Bengal, Orissa, Bihar, Maharashtra, Madras, Madhya Pradesh and Uttar Pradesh; it causes nasal granuloma in cattle, commonly known as the snoring disease. The beginning of the disease is indicated by constant running of the nostrils, associated with noisy breathing and occasional sneezing. Tartar emetic injections and sodium antimony tartrate are given for treatment. Destruction of snail hosts and treatment of dry canals with copper sulphate are effective means of control [Barlow, Amer. J. Hyg., No. 4, 1923; Bhalerao, Indian J. vet. Sci., 1932, 2, 338; 1933, 3, 120; 1934, 4, 148; Datta, ibid., 1932, 2, 9; Mahajan, ibid., 1942, 12, 133; Thapar & Sinha, ibid., 1945, 15, 219; Cameron, J. Helminth., 1931, 9, 41; Thapar, J. Helminth. (Leiper Suppl.), 1961, 39, 179; Thapar & Tandon, Indian J. Helminth., 1953, 5, 121; Anantaraman, ibid., 1958, 10, 46; Chandler, Indian J. med. Res., 1926, 27, 14, 179; Gadgil & Shah, ibid., 1955, 43, 695; 1956, 44, 577; Indian J. med. Sci., 1952, 6, 760; Rao, Indian vet. J., 1943-44, 20, 235; Sen, ibid., 1948-49, 25, 453; Vaidyanathan, ibid., 1949-50, 26, 225; Srivastava, Proc. Indian Sci. Congr., 1960, pt II, 105].

Tapeworms (Phylum Platyhelminthes, class Cestoda)

Fn. Br. Ind., Cestoda, I & II, 1930.

Tapeworms are parasitic platyhelminthes possessing a flat ribbon-shaped body which is divided into a chain of single units (Proglottides), each representing a complete anatomical structure. These worms occur as parasites in the alimentary canal of vertebrates and each one is well adapted to suit its parasitic mode of life with suckers or sucking grooves on the head (scolex) besides a circlet of hooks on rostellum at its anterior end for attachment. Tapeworms do not possess any organs for locomotion and digestion. In the absence of an alimentary canal nourishment is absorbed through the entire surface of the body of the worm, which is freely exposed to the digested or semi-digested food in the intestines of the host.

Tapeworms give rise to intestinal diseases and may sometimes cause vomiting, when the proglottides may rise upwards into the stomach.

Two main subclasses of tapeworms are known, viz. *Cestodaria* (*Monozoa*), parasitic in fishes, having a body composed of only one segment bearing a single set of reproductive organs, and *Cestodia* (*Merozoa*), parasitic in other vertebrates, having a body composed of a series of segments, each containing a complete set of male and female reproductive organs. Most important of the parasitic species are *Taenia solium* Linn., *Echinococcus granulosus* (Batsch), *Hymenolepis nana* Blanchard, *Dipylidium caninum* Railliet, *Moniezia expansa* (Rudolphi), *Diphyllobothrium latum* Leuckart, etc. Larval forms of Tetrahyynchid tapeworms are beneficial inasmuch as their larval cysts have been reported to serve as nuclei for the formation of some of the finest pearls.

PORK TAPEWORM [*Taenia solium* Linn. (Order Cyclophyllidae, family Taeniidae)] is cosmopolitan in its distribution and is common in the intestines of man; the larval stage is found in the muscles of pigs. The parasite is very much elongated and is characterized by the possession of a pear-shaped scolex with four cup-shaped suckers radially arranged. In front there is a retractile rostellum armed with 28-32 hooks in two rows. Behind the scolex is a short neck followed by the strobila marked with transverse grooves dividing it into a large number of proglottides. In gravid segments the uterus is full of eggs, each one surrounded by a chitinous shell and two membranes. When the gravid proglottides are passed out in faeces and dry up, the eggs, which bear six hooks, are scattered about. If they are eaten by pigs at this stage further development takes place. The hexacanth embryo bores its way through the intestinal wall and comes to lie in the muscles of pig, where it swells up into a large bag, the bladderworm (Cysticercus). On the inner wall of the cyst of the bladderworm the scolex is developed as an invagination with four suckers and two rows of hooklets. During the consumption of raw or inadequately cooked infected pork by man, the scolex gets evaginated and attached to the wall of the intestine and begins to form proglottides at the free end to become an adult. It takes about 3-4 months in pig and 11-12 weeks in man to attain maturity. The adult worm may live for as many as twenty-five years, or even more in the human intestine.

Other organs or tissues commonly infected with cysticercus are the brain, eyes, muscles, liver and

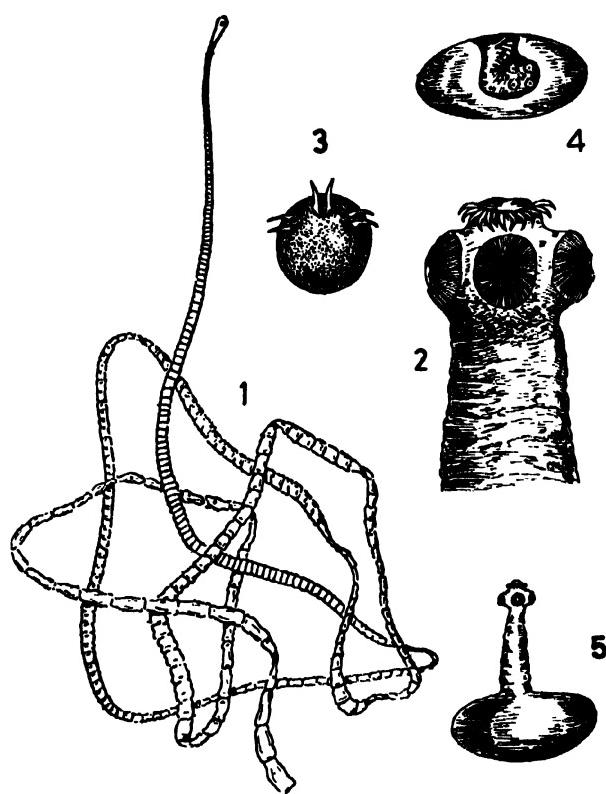


FIG. 103—PORK TAPEWORM (*TAENIA SOLIUM*)

1. Entire worm ($\times \frac{1}{2}$); 2. Head with suckers and hooklets on rostellum ($\times 12$); 3. Hexacanth embryo with hooklets ($\times 720$);
4. & 5. Bladderworm (*Cysticercus*) ($\times 3$)

lungs. Infection of the brain may cause epileptic fits, convulsions, paralysis, etc. In the eye it may seriously affect the vision. Persons of nervous temperament may suffer from anorexia, hyperesthesia and other nervous complications, which are due to the absorption of toxins produced by the worm. *Filix-mas** is administered as a cure; in case of *cysticercus* infection excision becomes necessary. Prophylaxis involves both personal hygiene and sanitary measures. Rigid inspection and examination of pork at public slaughter houses, and abstinence from eating raw and measly pork reduce the incidence of infection.

BEEF TAPEWORM [*T. saginata* Goeze] is common in beef-eating countries. The adult of this worm is much longer than the pork tapeworm, and is without any rostellar hooks in the head but possesses extra strong suckers. The intermediate hosts of this species are cows, buffaloes and some other bovines. Pathogenicity, therapeusis and prophylaxis are the same as for pork tapeworm.

Dog TAPEWORM [*Multiceps multiceps* Goeze (*Taeniidae*)] is characterized by having rostellum armed with hooks like that of pork tapeworm, but differs from the latter in possessing a pyriform head with double corona of hooklets of two different sizes. The intermediate host is sheep in which the developing hexacanth embryos bore their way through the intestinal wall, enter the blood stream and establish themselves in the brain. The embryos develop into bladderworms (*Coenurus*), which bear multiple heads projecting inwards. Each coenurus is capable of producing an adult worm. The adult worm gives rise to no particular symptoms in dogs, but the presence of coenurus in the brain of the intermediate host may produce gid or staggers. No treatment is possible. Care should be taken to prevent contamination from excreta of dogs in infected areas. During epidemic amongst sheep and goats, carcasses are burnt to prevent further infection of dogs.

Echinococcus granulosus (Batsch), a minute tape-worm, is found in dogs, cats, wolves and jackals. It is less than 12.7 mm. in length and consists of only four proglottides, besides the scolex; of these only the last proglottid bears genital organs and is thrown off when it becomes gravid. The scolex is crowned with double row of hooks besides four suckers. Only a few eggs are produced and this deficiency is made good by the asexual mode of reproduction during its larval stage. The eggs are expelled in the faeces of infected animals and they gain access to the intermediate hosts, such as cattle or sheep, through contaminated water. Occasionally man is also reported to get the infection from contaminated water or by allowing the dogs to kiss or lick. The hexacanth embryo perforates through the intestinal wall and migrates to any part of the body of the intermediate host, such as liver, kidney, lungs, spleen, intestinal wall, muscles or other parts, and develops into a bladderworm, which in about 5–6 months assumes the form of a small globular body, surrounded by a thick capsule secreted by the host. Inside this primary hydatid cyst, brood capsules or secondary daughter cysts are formed, which gradually increase in size and form a generation of asexual bladders. From the germinal wall of these secondary cysts, a number of scolices develop inwardly, each possessing suckers and hooks. In some cases the scolices are known to arise directly from the mother cyst wall also. Free brood capsules and free scolices occurring in the cavity of the hydatid cyst are known as the hydatid sands. When

taken by the definitive host the cyst is dissolved and each scolex grows into an adult worm.

The seriousness of hydatid cysts lies in the development of hydatid tumours on the organs or tissues in which they are implanted. The reaction of their presence may cause inflammatory and toxic symptoms at the seat of occurrence; if developed in brain or orbit, the situation becomes very serious and may result in death. To prevent the spread of disease in man, infected dogs should be segregated and prevented from having access to reservoirs of drinking water.

DWARF TAPEWORM [*Hymenolepis nana* (V. Siebold) (*Hymenolepididae*)] found in the human intestines, is fairly cosmopolitan in its distribution. It has a rhomboidal head provided with four suckers and a short rostellum armed with a single row of hooks. The egg is spherical and is hatched in the small intestines of the host. The entire development is completed in the villi of one host. Although it is the smallest of the human tapeworms (10-40 mm. long).

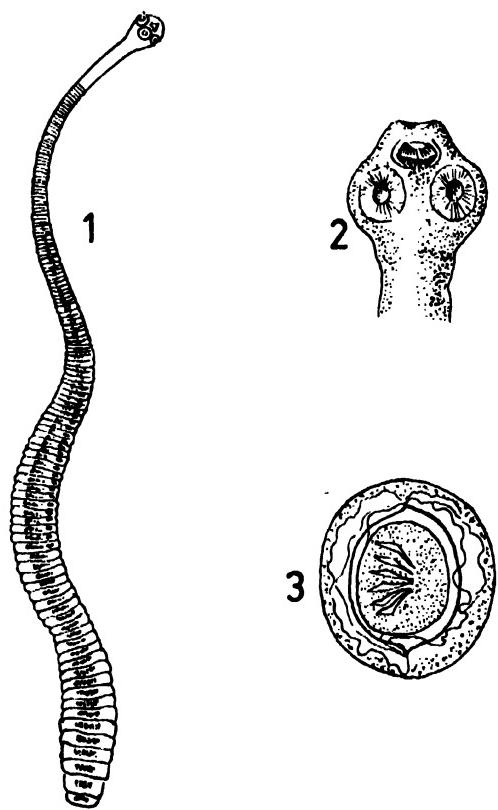


FIG. 104—DWARF TAPEWORM (*HYMENOLEPIS NANA*)

1. Entire worm ($\times 8$) ; 2. Head ($\times 200$) ; 3. Egg with hexacanth embryo inside ($\times 466$)

its toxic symptoms may give rise to severe reflexes, particularly in children. It produces abdominal pain, diarrhoea, convulsions, insomnia and epilepsy. Oil of chenopodium and extract of *Filix-mas* are given for expelling the worms. As the parasite can propagate without an intermediate host there is a danger of re-infection.

H. diminuta (Rudolphi), an allied species, is generally found in rats and mice but is also reported as an occasional parasite of man in India. The infection is due to accidental ingestion of food exposed to insects. The worm has an unarmed rostellum. Various insects, including cockroaches, serve as intermediate hosts of this tapeworm. As a preventive measure, food should be protected from pollution by insects.

Dipylidium caninum (Linn.) (*Dipylidiidae*), a common tapeworm of dog, is also reported from cat, hyaena, jackal and occasionally from man. It is found in the small intestines of the host and consists of a scolex with four suckers and a rostellum armed with four rows of hooks. The eggs are lodged in the perianal hairs of infected dogs and cats from where they are ingested by dog flea, *Ctenocephalus canis* Curtis, or by human flea, *Pulex irritans* Linn., and develop in the gut of the fleas. When these fleas are accidentally ingested by the mammalian host, the larvae, after liberation, attach themselves to the intestinal mucosa of the host and gradually become adults. The presence of these tapeworms in large numbers in dogs and cats produces no appreciable symptoms, except emaciation; but in children, intestinal disturbances and reflexes may occur. The human infection is mainly due to playing with infected dogs. *Filix-mas* is given as treatment.

Moniezia expansa (Rudolphi) (*Anoplocephalidae*), a common tapeworm occurs in cattle, sheep and goats in India. It is cosmopolitan in distribution. Its scolex and suckers are unarmed and the head is without a rostellum. The eggs have thin shells and the larvae are known to develop in the body cavity of oribatid mites of the genus *Erythracus* Latr., usually found in the soil. These mites get into the intestines of the cattle or other definitive hosts during grazing and are digested, liberating the cysticercoid larvae which develop into adults that remain attached to the intestinal wall of the host. A closely allied species, *Berticella satyri* (Blanchard), a tapeworm found occasionally in man and in higher apes, is also reported from India.

Diphyllobothrium latum Leuckart (Order *Pseudophyllidea*, family *Diphyllobothriidae*), a

PARASITIC WORMS

common tapeworm of seals and walruses in foreign countries, is found in dogs and cats in India, and may also be a potential human parasite. It is distinguished by its compressed cordate scolex, with two sucking grooves. The operculate eggs are oval and hatch out into ciliated oncospheres.

D. mansoni (Cobbold) is also a common parasite of dogs, cats, jackals, wolves, tigers and leopards. The eggs of the parasite are elliptical and its life-history passes through two intermediate hosts. The ciliated hexacanth embryo, after hatching from the egg, enters a cyclops larva of a copepod and transforms into a plerocercoid larva. At this stage if the cyclops gets entry into any one of the second intermediate hosts, viz. fish, frog, snake, bird or mammal, the plerocercoid larva works its way through the peritoneal surface of the intestines of the host and ultimately establishes itself in the muscles. As the development proceeds, it metamorphoses into a sparganum larva, multiplying itself by budding. It develops into an adult in the final host that happens to eat flesh of the infected second host. In man sparganum causes severe pain at the seat of infection and, at times, swellings of the eyelids. Therapeusis consists in the removal of the sparganum and draining of the lesion. The use of boiled and filtered water in endemic areas is helpful in checking the infection.

Tentacularia (Tetrahynchus) unionifactor (Herdman & Hornell) (Order *Tetrahynchidea*, family *Tetrahynchidae*) is a common tapeworm of the oyster-eating ray, *Rhinoptera javanica* Müller & Henle. Larval cysts of this worm are known to be attached to the intestinal walls of the oysters : they probably serve as nuclear cysts in the formation of fine pearls in the pearl-oysters, occurring in the pearl banks of Ceylon and India (Anantaraman, *Sci. & Cult.*, 1951-52, 17, 155 ; Cameron, *J. Helminth.*, 1926, 4, 13 ; Chandler, *Parasitology*, 1925, 17, 421 ; *Indian J. med. Res.*, 1926-27, 14, 973 ; Maplestone & Bhaduri, *ibid.*, 1937-38, 25, 155 ; Maplestone, *Indian med. Gaz.*, 1933, 68, 377 ; 1937, 72, 149 ; Maplestone & Mukerji, *ibid.*, 1939, 74, 195 ; Southwell & Prashad, *J. Parasit.*, 1918, 4, 122 ; Hornell, *J. Asiatic Soc. Beng.*, N.S., 1922, 18, 215 ; Thapar, *Proc. Indian Sci. Congr.*, 1936, pt III, 348 ; 1937, pt III, 274).

Roundworms (Phylum Nematoda)

Fn. Br. Ind., Nematoda, I, 1936 ; II, 1939.

Nematodes or roundworms are unsegmented, possessing a mouth and alimentary canal throughout their life. The body is rounded or pointed at both

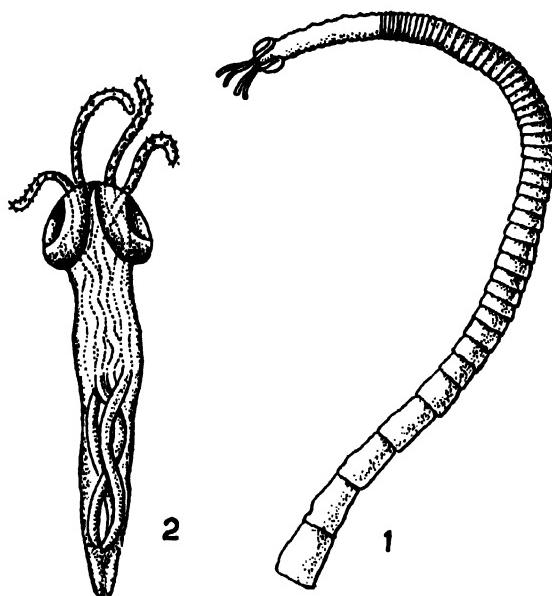


FIG. 105—TAPEWORM (*TENTACULARIA UNIONIFACTOR*)

1 Entire worm ; 2. Larva (x100)

extremities. Roundworms include both parasitic and free living forms. Parasitic forms are found in man, domestic animals, plants and insects. Life-history of these parasitic nematodes is of variable types ; in a few forms it may be completed through intermediate hosts, such as insects.

Nematode parasites of man and domestic animals are generally found in the intestines, stomach and other related digestive organs ; a few others occur in lymphatic glands, subcutaneous tissues, muscles, etc.

Ascaris lumbricoides Linn. (Order *Ascaroidea*, family *Ascaridae*), cosmopolitan in its distribution, is a common intestinal parasite of man and is also found in pigs. The worm is elongated, cylindrical and yellowish brown, marked with longitudinal streaks along the dorsal, ventral and lateral sides of the body. The mouth is surrounded by three fleshy lips, each provided with two minute papillae.

The fertilized eggs bear a coarse mammillated covering and can withstand a long period of desiccation, extending to over five years. When taken by the host, the intestinal juices stimulate the activities of the enclosed larva, which emerges as rhabditiform larva in about 9-13 days. It moults and pierces through the intestinal wall to migrate into the lymphatics and other organs, such as heart, lungs, etc., from where it filters out into the alveoli and after

a period of growth returns to the intestines by passing through the bronchii, trachea, oesophagus and stomach, where it grows into adulthood in about 2-2½ months after infection.

The larvae may produce oedema of the lungs and symptoms resembling lobar pneumonia. The adult worms produce digestive disturbances, resulting in toxæmia and nervous complications. Occasionally they may wander up the stomach and cause vomiting, or may perforate the intestinal wall, giving rise to peritonitis. Proper disposal of nightsoil and good sanitation are most effective measures for reducing infection.

A closely allied species, *Parascaris equorum* (Goeze), found in horses, causes little disturbance. *Toxascaris canis* (Warner) is a common parasite of dogs.

PINWORM OR SEATWORM of man, *Enterobius varmicularis* (Linn.) (Oxyuridae), cosmopolitan in distribution, is a small intestinal parasite with a swollen cuticle round the head. The tail of the male is truncated and strongly curved. The adult worms live in the lower parts of the intestines, causing itching sensation at the anus. The infection is due to eating raw vegetables or other food polluted by eggs that are scattered about by flies visiting infected faecal

matter. Children may also acquire the infection while playing in dirty localities. The worm causes inflammation round the seat of attachment and may occasionally wander upwards to the appendix, causing inflammation which may result in appendicitis. Irritation of the perineum may give rise to sexual disorders and at times to nervous symptoms. Santonin, oil of chenopodium, thymol, hexylresorcinol and the proprietary product Antipar, are recommended for the elimination of the worms. Sanitary measures should be taken to prevent infection.

HOOKWORM of man, *Ancylostoma duodenale* (Dubini) (Order Strongylidea, family Ancylostomidae) is attached to the mucous membrane of the intestines by its anterior end and is characterized by the presence of a deep cup-shaped buccal capsule, bent dorsally round the mouth. The orifice is guarded by two pairs of large hook-like teeth. The eggs are passed out along with faeces. They can withstand desiccation of a long time and on hatching produce rhabditiform larvae in the sand. Later they metamorphose into filariform larvae which, after two ecdyses, pierce through the skin of the host to enter into the blood stream and migrate into various organs of the body of the host, such as heart, lungs, larynx, etc., and ultimately, through the gullet and stomach, reach the intestine, where they form side capsules. After further ecdyses they attach themselves to the mucosa of the duodenum and become adults. The presence of hookworms in man causes mental and physical sluggishness, anaemia, malnutrition, endocrine deficiency and complete degeneracy.

A combination of oil of chenopodium and carbon tetrachloride, followed by magnesium sulphate, is more effective. Proprietary drugs like Bayer's Ascaridole and Neo-bedermic followed by a purging dose of castor oil or saline are also reported to have better effect. Proper disposal of the night soil and keeping off the polluted soil when bare footed are some of the preventive measures.

A closely allied species, *A. caninum* (Ercolani), is the common hookworm of dogs and cats and is differentiated from the hookworm of man by the possession of three teeth on each dental plate instead of two. The infective filariform larvae produce a mild dermatitis in man.

A number of hookworms are also found in ruminants. The most prominent among them belong to the genera *Monodontus* Molin and *Bunostomum* Railliet, which are characterized by the presence of cutting plates along the anterior margin of the

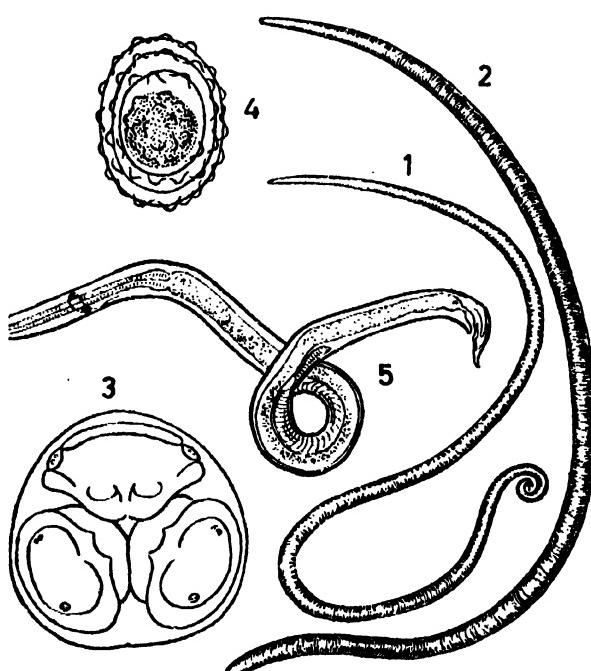


FIG. 106—ROUNDWORM (ASCARIS LUMBRICOIDES)

- 1 & 2 Male and female worms ($\times 3$) ; 3 Head end showing lips ($\times 40$)
4. Fertilized egg ($\times 340$) . 5. Larva, 8 days old ($\times 195$)

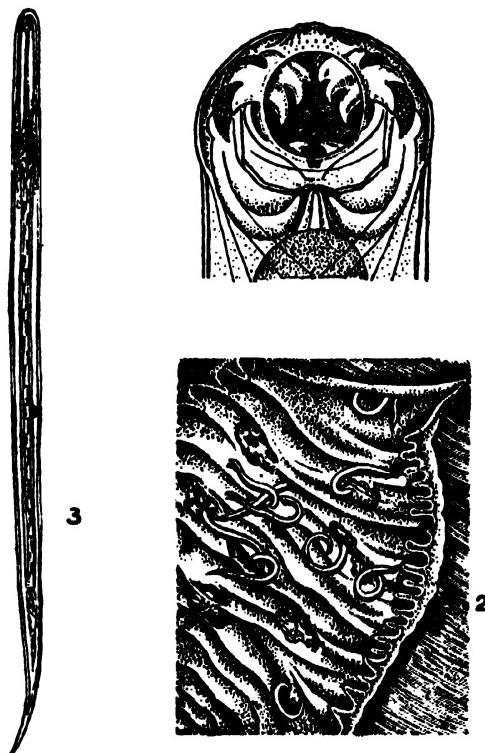


FIG. 107—HOOKWORM (ANCYLOSTOMA spp.)

A. caninum—buccal capsule showing teeth ($\times 110$) ; 2. A. duodenale—intestinal wall with hookworms ($\times 15$) ; 3. Filariform larva ($\times 118$)

buccal capsule instead of teeth as found in *Ancylostoma*. Clinical symptoms are not known, but being tissue feeders, they may cause considerable damage. The general symptoms, like anaemia, dropsy and malnutrition are apparent. Carbon tetrachloride and phenothiazine are used as vermicides.

Oesophagostomum (Bosicola) radiatum (Rudolphi), *O. (Hystericrum) indicum* (Railliet & Henry) and *O. (Proteracrum) columbianum* (Curtice) (*Strongylidae*) are commonly found in Indian cattle, sheep and goats and are characterized by the possession of short cylindrical buccal capsule with a number of leaf-like processes at the anterior end. They cause nodular tumours of the intestines and, if present in large numbers, cause anaemia, emaciation, diarrhoea and dropsy. Phenothiazine is effective as a curative drug.

Species of *Triodontophorus* Looss, *Strongylus* Müller and *Trichonema* Cobbold are parasitic in the caecum of horses. They all cause strongylidosis with symptoms of anaemia and occasional diarrhoea, resulting in oedema and emaciation. Phenothiazine is

effective in killing both the adult worms and the eggs. Phenovis (brand of phenothiazine) is considered a valuable drug for the general treatment of the worms.

STOMACHWORM OR WIREWORM of ruminants, *Haemonchus contortus* (Rudolphi) (*Trichostrongylidae*) is one of the commonest parasites attached to the walls of the stomach in sheep, goats and cattle throughout the world. It is small, thin and wire-like, with a single protrusible pharyngeal lancet in the buccal cavity. The eggs of the worm hatch out into rhabditiform larvae, which remain inside the sheath and after several days metamorphose into ensheathed infective filariform larvae. They enter the final host, cast off the skin and moult before becoming sexually mature. Anaemia and watery swellings under the jaws (bottle-jaw) of the host become apparent. The faeces become dark and fluid. Thymol and Phenovis are employed as a cure. Rotation of crops to obtain uninfected grazing fields is an effective method of controlling the infection.

Mecistocirrus digitatus (Linstow) is a very common parasite found in the stomach and the adjacent portions of the intestines of the sheep, goats, cattle and even pigs in India, causing pathological symptoms similar to those of the stomachworms. *Ostertagia ostertagi* Ransom is a threadworm also found in the form of cysts in the stomach wall of the cattle. It causes digestive troubles in the host with symptoms similar to those of the stomachworm. Medical treatment is of little value.

LUNGWORM, *Varestrongylus pneumonicus* Bhalerao (*Protostrongylidae*) is reported from the bronchioles of sheep and goats of certain hilly tracts of Uttar Pradesh and W. Bengal, giving rise to verminous pneumonia or bronchitis. It is distinguished by the absence of the buccal capsule. Spasmodic cough is a significant symptom of the disease, leading to emaciation, anaemia and debility. Thick nasal discharge flows and often the host dies. No treatment seems to be effective, but administration of proper doses of chloroform is suggested. Other forms like *Dictyocaulus filaria* (Rudolphi), *Protostrongylus rufescens* Kamensky and *Mullerius capillarius* (Muller) are also reported to cause verminous pneumonia in sheep and goats in various parts of India.

Habronema muscae (Carter) (Order *Filarioidea*, family *Spiruridae*) is a common parasite of horses in India. It is characterized by the possession of four lips followed by a cuticular vestibule in front of the mouth. The eggs or larvae of this worm are ingested

by larvae of the housefly from horse manure. During the metamorphosis of the housefly, the larvae of the worms enter the malpighian tubules and migrate into the proboscis of the adult fly. The fly transmits these larvae to the open sores, lips, etc., of the final host, from where they migrate through different parts of the body and find their way to the intestines to become adults. In the initial larval stages this parasite causes chronic inflammation of the skin and the subcutaneous tissues of horses, forming granulations leading to degenerative lesions (*barsati* disease) at the seat of the saddle. Treatment is not known but carbon bisulphide may sometimes be effective. Gastric habronemiasis is caused by the adult worms. Destruction of flies and proper control of manure may help in prevention of the disease.

Gongylonema pulchrum Molin (*Gongylonemataidae*) is a common parasite of ruminants in India and is recognized by the presence of oval or rounded tubercles on the anterior part of the body in both sexes. It is found below the epithelium of the oesophagus of the host. Dung-beetles act as intermediate hosts.

Thelazia rhodesii (Desmaret) (*Thelaziidae*) occurs in the lachrymal glands of cattle and horses. It is a small slender worm with no lips. The worm causes inflammation of the conjunctiva in the cattle. Iodoform ointment may prove effective, but if the worm enters the eye it can be removed only by surgery.

Spirocerea sanguinolenta (Rudolphi) is a common parasite of dogs. The worm is reddish in colour. Intermediate hosts are beetles and cockroaches.

FILARIAL WORM | *Wuchereria bancrofti* (Cobbold) (*Filariidae*) is a common parasite of man in India and is cosmopolitan in distribution. The adult is found coiled up in the lymphatic glands of the host and causes elephantiasis by interfering with lymphatic circulation. The worm is slender in form with a bulbous head and simple mouth without lips and vestibule. The eggs develop inside the female into slender microfilariae, enclosed in a transparent sheath, and reach the blood through lymph streams, whence they may be sucked by a female mosquito (*Culex fatigans* Wiedemann). The microfilariae escape from the sheath and wriggle about in different parts of the body of the mosquito, ultimately entering the proboscis. Many of them pass down the labium, and when the mosquito bites a human being they emerge from it on the surface of the skin and penetrate through the skin by active boring and re-establish themselves in the lymphatics as adults. The mecha-

nical obstructions caused by the worms result in the enormous growth of the infected parts, such as the lymphatics of abdomen, pelvis, groins, scrotum, etc. The skin of the affected parts becomes thickened and hardened. No drug seems to be specific but Saomin, Fouadin and oil of chenopodium may be of some help. Antimosquito measures are adopted as prophylaxis.

Parafilaria multipapillosa (Condamine & Drouilly) is a small worm found in the subcutaneous region of horses, causing haemorrhage at various points. Similarly *Dirofilaria immitis* (Leidy) is found in dogs. Life-history in both cases is not known.

Stephanofilaria assamensis Pande is reported from Assam, W. Bengal and Orissa, as the causal agent of hump sore of cattle. The parasite is characterized by the presence of double rows of cuticular spines round the mouth and transversely striated body. The sores are quiescent during winter but reappear during rains and become ulcerated by repeated acts of rubbing against hard surfaces : deposition of eggs by the flies in the lesions results in Myiasis.

Many species of *Onchocerca* Diesing occur in the cattle, horses and camels. Species of flies belonging to the genus *Simulium* Latr. are reported to serve as intermediate hosts.

GUINEAWORM or MEDINAWORM of man, *Fulicornius medinensis* (Linn.), is more than a metre long, thread-like and without anus. It occurs in the deeper layers of subcutaneous tissues. The male is practically unknown. The female is viviparous and the larvae are discharged into water where they enter a cyclops and undergo metamorphosis. They (infected cyclops) are accidentally ingested by the final host along with drinking water. The worms are generally found in the muscles of the leg and feet and are usually extracted by winding out on a hot iron rod, but they cannot be easily separated. The presence of the worms causes nausea, vomiting, diarrhoea and giddiness in the host, due to the production of toxic secretions. Localized lesions consist of small reddish papules on the skin of the extremities, particularly near the foot, which often rupture, passing out yellow fluid containing guineaworm larvae. Step-wells are the most common places of infection in India. Proper care should be taken to avoid contamination of drinking water. Use of chemicals that kill the cyclops, without polluting the drinking water, is helpful in controlling fresh infections. The Guineaworms have been reported also from dogs, horses, cattle, leopards, monkeys and baboons.

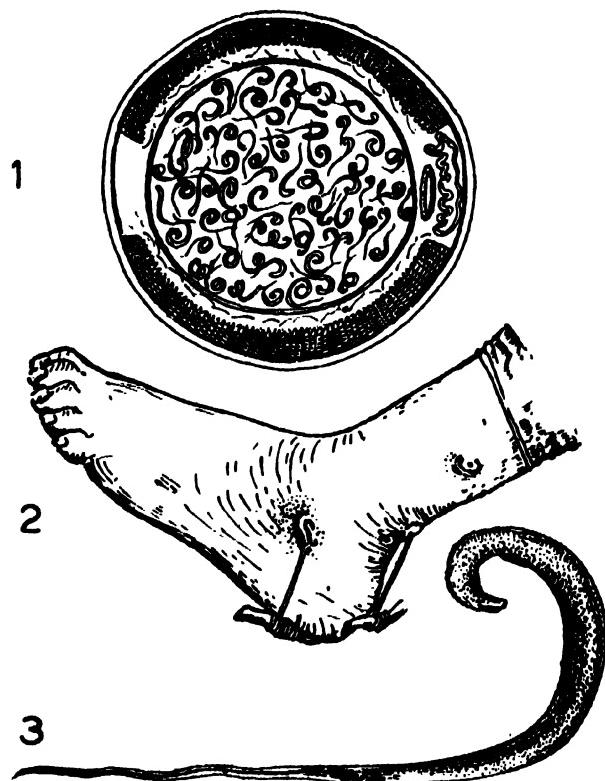


FIG. 108—GUINEAWORM (FULLEBORNIA MEDINENSIS)

interns showing larvae ($\times 30$) Guinea worm
d from human toe 3. Larva ($\times 156$)

WHIPWORM, *Trichuris trichiura* (Linn.) (Order *Trichinelloidea*, family *Trichinellidae*) is principally a parasite of human beings. It lies buried in the folds of the wall of the large intestine by its elongated thread-like anterior part. Usually no symptoms are produced but sometimes the infection may cause diarrhoea, vomiting and nervous disorders. The infection is direct by the ingestion of barrel-shaped eggs which mature in a month's time. No specific treatment is known; oil of chenopodium, however, is said to dislodge the worms.

Trichinella spiralis (Owen) is one of the smallest worms of the family (1.5 mm. long). It is found coiled up in the muscles of rats, pigs and man. The infection in man is spread through eating raw infected pork. The cysts dissolve in the stomach and the parasites, after maturation, deposit their larvae in the deep mucosa, whence they enter the lymphatics and are carried to all parts of the body. Here they form cysts once again and the encysted larvae get calcified after

a few months. Gastro-intestinal symptoms, such as nausea, vomiting, diarrhoea and dysentery occur in early stages of infection, followed by rheumatic muscular pains, myositis, oedema, hypereosinophilia and other complications. Careful inspection of meat at the slaughter-houses may considerably reduce the incidence of the disease. An extract of *Trichinella* larvae is used in an intradermal skin test for trichinosis (Basu, *Calcutta med. J.*, 1939, **35**, 114; Baylis, *J. comp. Path.*, 1925, **38**, 46; Srivastava, *Indian J. vet. Sci.*, 1939, **9**, 309; Anantaraman, *ibid.*, 1942, **12**, 87; Bhalerao, *ibid.*, 1939, **9**, 371; *Curr. Sci.*, 1945, **14**, 106; Cameron, *J. Helminth.*, 1923, **1**, 205; Chandler, *Indian J. med. Res.*, 1926-27, **14**, 185, 457, 733, 955; 1927-28, **15**, 143; Chopra & Rao, *ibid.*, 1939-40, **27**, 549; Lane, *ibid.*, 1916-17, **4**, 74; Iyengar, *ibid.*, 1941, **29**, 677; Maplestone & Mukerji, *Indian med. Gaz.*, 1940, **75**, 193; Napier, *ibid.*, 1941, **76**, 161; Maplestone & Bhaduri, *ibid.*, 1942, **77**, 193; Patel, *Indian J. med. Sci.*, 1948, **2**, 151; Ransom & Cram, *Amer. J. trop. Med.*, 1921, **1**, 129; Deshmukh, *Antiseptic*, 1940, **37**, 348; Ratna, *ibid.*, 1942, **39**, 205; Martin, *Bull. Univ. Neb. agric. exp. Sta.*, No. 37, 1926; Ransom, *Bull. U.S. Bur. Anim. Ind.*, No. 163, 1913; Veglia, *Rep. vet. Res. S. Afr.*, 1915, 349).

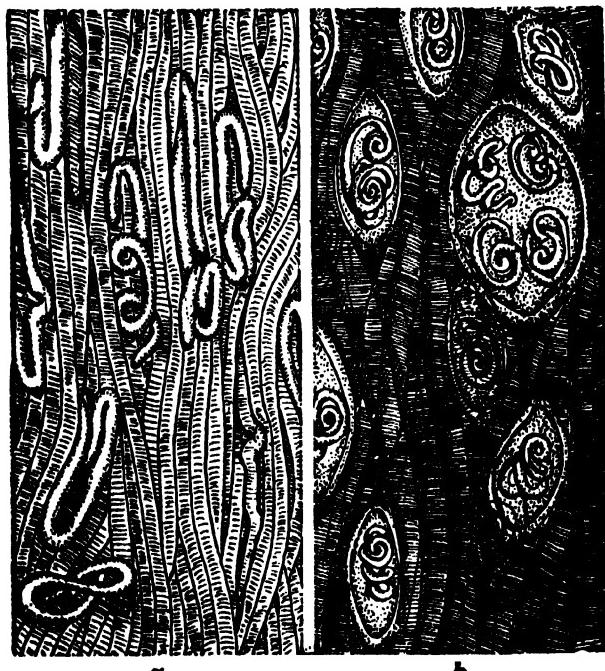


FIG. 109—TRICHINELLA SPIRALIS

& b: Larvae before and after encystment ($\times 15$)

Nematode parasites of plants (Order *Tylenchida*) are mostly soil-dwelling forms, found in the region of roots. About 100 species are known in the world to be obligate plant parasites, living as adults within or at least firmly attached to the plant tissues. The severity of damage caused to some common horticultural and agricultural crops by a few known parasites has been an important factor in the economy of this country. Many of these parasites seem to have specific host preferences. The following plant parasitic nematodes are reported to occur in India.

Anguina tritici Steinbuch (*Tylenchidae*) is a common parasite of cereals, producing black gall-like 'cockles' in the grains; it may also occur in the roots and other parts. The larvae show extraordinary resistance to adverse conditions, tiding over the unfavourable situations even up to twenty years. Rice root-nematode, *Hirschmanniella oryzae* Luc. & Goodey [= *Radopholus oryzae* (v. Breda de Haan)] of the same family is a common parasite of paddy in Bihar, larvae penetrating the roots almost anywhere except the growing point. Maintenance of fertility of the soil may help to produce good crops on heavily infested lands. The root-lesion nematode, *Paratylenchus pratensis* (de Man) is a minute parasite of tomato crops in Delhi and surrounding areas. Reniform

nematode, *Rotylenchulus reniformis* Linford & Oliveira, is a serious pest of papaya trees in N. India, and is also found to occur in *Mangifera indica* Linn. and *Citrus limon* Burm. f. in Aligarh, Banda, Haldwani and Jhansi.

Cyst-forming nematodes belong to the family *Heteroderidae* and the larvae are reported to occur as pests on the roots of a number of food, vegetable and cereal crops. Cereal root-eelworm, *Heterodera avenae* (Mortensen *et al.*) is reported to be parasitic on wheat and barley crops in Rajasthan, producing *molya* disease, which is spotted out in the field by the presence of stunted and pale-looking plants; damage caused may amount to 50% of the crop. The nematode is far more serious in barley than in wheat fields.

GOLDEN NEMATODE OR POTATO-ROOT-EELWORM, *H. rostochiensis* Woollenweber, is a serious pest of potatoes in Nilgiris. Injury becomes evident when young potato plants, after having utilized the stored food in the seed, begin to depend on their own roots for nourishment. Severe infestation checks plant's growth and causes wilting. Rotation of crops is a practical method of controlling the pest in the soil. Soil fumigation with D-D (mixture of 1,3-dichloropropene and 1,2-dichloropropane) may also be beneficial. Clover cysts nematode, *H. trifolii* (Goffart), usually associated with white clover in lawns and pastures, is also reported on *arhar* plant [*Cajanus cajan* (Linn.) Millsp.] in Delhi and nearby areas. Plants, infested by this nematode, wilt during summer.

ROOT-KNOT NEMATODES, *Meloidogyne* spp., belonging to the same family, are responsible for gall formations in cereals and vegetables and in plantation crops, such as tea, coffee, etc. *Meloidogyne javanica* (Trueb) is reported to cause root-knots in sugarcane in India. *M. incognita* (Kofoid & White) is a pest on papaya tree. Infested plants show reduced growth and wilt in warm weather. Females are typically elongate and pyriform and are usually found attached to the roots of the host plants by their anterior ends. Root-knot nematode injury is usually associated with and accentuated by certain plant parasitic fungi. Rotation of crops is seldom helpful in controlling these nematodes because of wide variety of their hosts.

CITRUS NEMATODE, *Tylenchulus semipenetrans* Cobb (*Tylenchulidae*), is a parasite of citrus plants causing considerable loss of fruit. The first indication of injury is a reduction in terminal growth, which is followed by a general appearance of reduced vigour

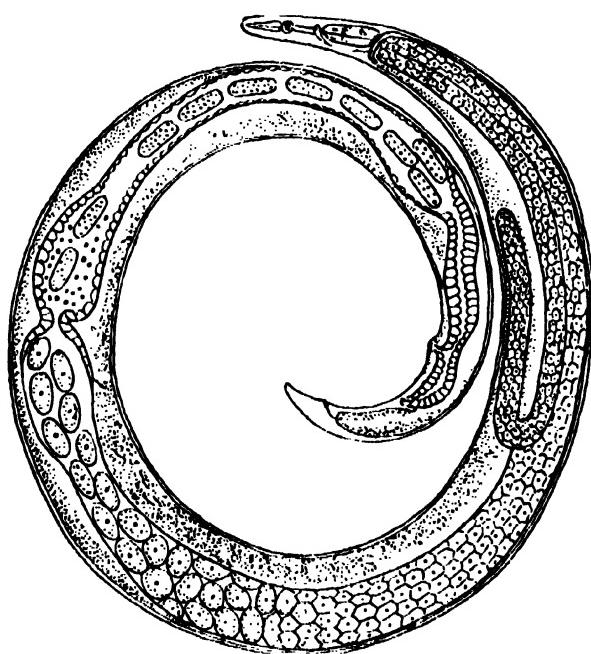


FIG. 110—ANGUINA TRITICI—ADULT (X90)



I.A.R.I., New Delhi

FIG. III—ROOT-KNOT ON *LUFFA CYLINDRICA* ($\times 1$)

and yellowing and dying of leaves and twigs. Clean nursery stock and fumigation of infested fields with D-D are useful control measures. Effective control is possible by adding DBCP (1,2-dibromo-3-chloropropane) to the irrigation water.

Control measures—The possibilities of complete eradication of nematode parasites of plants are exceedingly remote except, perhaps, in a few isolated cases; but control may be effected through crop rotation, cultivation of nematode-resistant plant strains, soil fumigation, etc. Time of planting and harvesting may be so combined with plant rotation that the periods of high nematode activity are avoided. Preferential nematodes may be deprived of their hosts for three or four years, and sowing may be done when the nematode population has fallen to a point where a profitable crop may be feasible. In dry and hot climates the land may be left fallow and ploughed two or three times so as to expose the nemas to intense heat, when they perish from

desiccation. Tear gas, D-D and EDB (ethylene dibromide) are some of the more important fumigants. Tear gas, used principally in nurseries and green houses, is an effective nematicide and fungicide; D-D and EDB are used for roadside dressings and spot treatment (Goodey, 1-306; *Thapar Commemoration Volume*, Lucknow, 1953, 95; Thorne, 26-35, 160-61, 217-20, 233, 245-46, 304-09, 312-21; Singh, 1963, 348-68; Gadd, *Tea Quart.*, 1939, 12, 131; Barber, *Bull. Dep. Ld Rec. Agric. Madras*, 1901, 2, 227; Sanyal, *Indian J. Helminth.*, 1951, 3, 59; Chauhan & Ramakrishna, *ibid.*, 1958, 10, 64; Prasad, *Indian J. Ent.*, 1961, 23, 230; Swarup & Singh, *Indian Phytopath.*, 1961, 14, 127; Luthra & Vasudeva, *Curr. Sci.*, 1939, 8, 511; Thirumalachar, *ibid.*, 1951, 20, 104; Rangaswami *et al.*, *ibid.*, 1961, 30, 149; Jones, *ibid.*, 1961, 30, 187; Dastur, *Proc. Indian Acad. Sci.*, 1936, 4B, 108; Rafay *et al.*, *Proc. Indian Sci. Congr.*, 1942, pt III, 218; Kundu, *ibid.*, 1946, pt III, 113; Siddiqi, *ibid.*, 1961, pt III, 504; Thapar, *ibid.*, 1941, pt III, 228; *Progress of Science in India. Sec. Zoology*, subsec. *Helminthology*, 1956, 152-69; Venkatarayan, *J. Indian Bot. Soc.*, 1932, 11, 243).

A few species of nematodes belonging to the families *Thelastomatidae* and *Oxyuridae* (Order *Oxyuroidea*) have been reported to occur as parasites in the intestines of some common insects, such as cockroaches, mole-crickets, aquatic beetles, etc., in India. Very little is known about these parasites.

Spiny-headed worms (Phylum *Acanthocephala*)

Spiny-headed worms are characterized by having three distinct parts of the body, viz. the proboscis, the neck and the body proper. Alimentary canal is significantly absent. The relationship of these worms with nematodes is doubtful, since they possess such structural peculiarities as to be classified under a distinct phylum. They have been reported from a variety of vertebrate hosts in India, viz. fishes, amphibia, reptiles, birds and mammals. The larval forms are found to occur in insects and aquatic arthropods.

A large number of spiny-headed worms are known to occur in the lower vertebrates. *Macracanthorhynchus hirudinaceus* (Pallas) is the giant worm of pigs. Cases of infection have also been reported in human beings. It is white in colour and has a rugose appearance with a transverse pseudo-segmentation. The proboscis serves for attachment to the intestinal wall of the host, and is provided with five or six rows of recurved spines. It is retractile

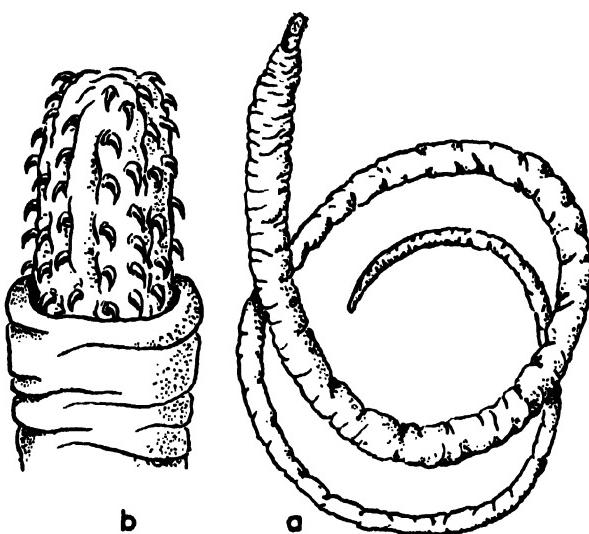


FIG. 112—SPINY-HEADED WORM (*MACRACANTHORHYNCHUS HIRUDINACEUS*)

(a) Entire worm ($\times 1$) ; (b) Head ($\times 10$)

inside a proboscis sheath. The eggs hatch in various species of beetles which are ingested by the mammalian host. The attachment of the proboscis in the host causes localized inflammation, with infiltration of eosinophiles, resulting eventually in necrosis.

Moniliformis moniliformis (Bremser) is a common parasite of rodents and a facultative parasite in man. It has a cylindrical proboscis armed with twelve to fifteen rows of hooks : each row containing seven to eight of them. The eggs are ellipsoidal and the embryos are covered with spines. The intermediate hosts are species of cockroaches and possibly other insects in whose body the embryos develop into oval larvae enclosed in a cystic capsule. Infection of the mammalian hosts may be due to the accidental contamination of food exposed to insects. Its occurrence in man results in severe gastro-intestinal pain and diarrhoea, accompanied by exhaustion and pronounced ringing of the ears. Administration of Filix-mas is reported to afford some relief (Hoffman, *J. Parasit.*, 1930, **16**, 169; Kates, *J. agric. Res.*, 1941, **64**, 23; *Amer. J. vet. Res.*, 1943, **5**, 173; Sita, *Curr. Sci.*, 1949, **18**, 216).

PARASTEMON A. DC. (*Rosaceae*)

Fl. Br. Ind., II, 312.

A small genus of trees distributed in the Indo-Malaysian region. One species occurs in India.

P. urophyllum A. DC. is a medium-sized tree, c. 1.8 m. in girth, with elliptic-lanceolate leaves and small creamy white flowers found in the Nicobar Islands. It yields a dark brown wood with straight or slightly interlocked grain and moderately fine texture; it is very hard and heavy (av. wt., 1,025 kg./cu.m.), but not resistant to shock. The wood can be air-seasoned without much degrade, but has a tendency to warp and twist. It is fairly durable, and because of its high silica content may prove resistant to marine borers. Though difficult to saw, it can be planed to a smooth finish. The wood is used in Malaya and Borneo for general construction and posts : it is also considered a good fuelwood. It may be suitable for bridges, salt-water piling, turnery and carving (Burkill, II, 1665; Browne, 308; Desch, 1954, 479-80).

PARINARI Aubl. (*Rosaceae*)

Fl. Br. Ind., II, 308.

A genus (syn. *Parinarium* Juss.) of trees or shrubs distributed throughout the tropics. Two species occur in India.

P. travancoricum Bedd. is a small to medium-sized graceful tree with a straight cylindrical bole found in Kerala up to an altitude of 600 m. It furnishes a wood which is bright pink, close- and even-grained, smooth, hard and heavy (wt., 785 kg./cu.m.). The wood of an allied species *P. corymbosum* Miq. syn. *P. griffithianum* Benth., found from Burma to Philippines, is reported to be resistant to marine borers and is used for salt-water piles and ship building. The seed kernels yield c. 79% of a fatty oil which dries quickly on exposure (Gamble, 311; Bourdillon, 145; Browne, 309; Burkill, II, 1666; Eckey, 472; *Chem. Abstr.*, 1941, **35**, 4984).

It would be worthwhile to investigate if the wood and seeds of *P. travancoricum* can be similarly used.

PARIS Linn. (*Liliaceae*)

A small genus of rhizomatous perennial herbs distributed in Europe and temperate Asia. One species occurs in India.

P. polypylla Sm.

Fl. Br. Ind., VI, 362.

A glabrous erect herb, 30-45 cm. high, with thick, creeping rootstock found in the temperate Himalayas at altitudes of 1,500-3,000 m. from Simla to Bhutan, and in Lushai and Aka hills. Leaves lanceolate, arranged in a whorl at the summit of the stem

PARIS

with a solitary flower in the centre : outer perianth green, inner yellow or yellowish green ; capsules globose, yellowish brown with numerous scarlet seeds.

The rhizome of the plant contains sugars (7.9%) and two glucosides, viz. α -paridin (m.p. 244-46°) and α -paristyphnin (m.p. 147-49°), which produce a tingling sensation on the tongue. α -Paristyphnin, which is pharmacologically more active, has a depressant action on carotid pressure, myocardium and respiratory movements. It produces vasoconstriction in kidney, but vasodilatation in the spleen and limbs, and stimulates isolated intestines : these actions are not modified by atropine or ergotoxine (Dutt *et al.*, *Arch. Pharm., Berl.*, 1938, **276**, 343 ; Chopra *et al.*, *Indian J. med. Res.*, 1942, **30**, 103).

The rhizome possesses anthelmintic properties : its powder taken with hot water is used as a tonic (Hoppe, 642, Roi, 81).

PARISHIA Hook. f. (*Anacardiaceae*)

A small genus of trees distributed from the Andaman Islands and Burma eastwards to the Philippines. One species occurs in India.

P. insignis Hook. f.

Fl. Br. Ind., II, 29 ; Corner, I, 112, Fig.

TRADE—Red dhup (wood).

A large tree, up to 40 m. in height and 3.6 m. in girth, found in the Andaman Islands. Bark grey, peeling off in flakes ; leaves large, imparipinnate : leaflets ovate-oblong, oblique ; flowers in long panicles, yellow, small ; fruit a hairy nut, c. 1.25 cm. in diam., surrounded by four enlarged wing-like sepals.

The tree yields a valuable board wood. Sapwood is wide and whitish in colour : heartwood light pinkish grey ageing to pale brownish grey, lustrous when freshly cut but soon becoming dull from grey fungal stain, straight- or slightly interlocked-grained, coarse- and even-textured, soft and light (sp. gr., 0.491 : av. wt., 497 kg./cu.m.). The wood seasons easily without splits or warps; green conversion and open stacking of boards under cover are recommended. It can also be kiln-seasoned without difficulty : 2.5 cm. thick planks take 4-5 days to season without any defects. The wood is not durable in the open, but is fairly so under cover. It is easy to saw and work to a smooth surface. The data for the comparative suitability of timber expressed as percentages of the same proper-



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FIG. 113—PARISHIA INSIGNIS

ties of teak are: weight, 70 ; strength as a beam, 50 : stiffness as a beam, 75 : suitability as a post, 55 : shock resisting ability, 50 : retention of shape, 65 : shear, 75 : and hardness, 40 (Pearson & Brown, I, 340-41 ; Limaye & Sen, *Indian For. Rec., N.S., Timb. Mech.*, 1953, I, 94 ; Rehman, *Indian For.*, 1953, **79**, 369 ; Purushotham *et al.*, *ibid.*, 1953, **79**, 49 ; Limaye, *Indian For. Rec., N.S., Timb. Mech.*, 1954, I, 56, Sheet No. 15).

Red dhup is very suitable for match-boarding, bottoms and backings of drawers and cupboards, wainscoting and partition work. It is also suitable for plywood, especially for tea chests, chip boards and for rafting heavy timber (Pearson & Brown, I, 341 ; *Indian For.*, 1952, **78**, 287 ; Burkill, II, 1668 ; Prasad, *Res. & Ind.*, 1957, **2**, 293).

PARKIA R. Br. (*Leguminosae* ; *Mimosaceae*)

A genus of trees distributed throughout the tropics. One species occurs in India and another has been introduced for its ornamental value.

P. biglandulosa Wight & Arn.

Fl. Br. Ind., II, 289.

KAN.—*Sivalinga mara*.BOMBAY—*Chenduphul*.

A tall handsome evergreen tree, native of Malaya, grown in gardens and on roadsides in many parts of India, especially in the South. Leaves large, bipinnate, with numerous small leaflets; flowers in globular heads hanging on long peduncles, small, velvety-brown at first, later turning white; pods c. 30 cm. long narrowed gradually into a long stalk.

P. biglandulosa is a good avenue and shade tree and looks very attractive with its feathery foliage and brown and white pendant flowerheads. It can be easily propagated from seed and has a fast rate of growth, attaining a height of c. 16 m. and a girth of 1.1 m. in 15 years (Gopalaswamiengar, 235; Haines, III, 321).

The farinaceous pulp of the pods is reported to be edible. Flowerheads discharge a lot of pollen which mixed with water makes a refreshing drink. Sprouted seedlings are said to be eaten in Malaya. Bark is astringent and used in tanning. Wood is hard and good (Rama Rao, 148; Cameron, 115; Corner, I, 415).

The seeds yield (16.5%) a fatty oil of a pale yellow colour and characteristic odour; it has the following constants: sp. gr.^{15°}, 0.9208; n_{D}^{21} , 1.4705; sap. val., 189.5; iod. val., 80.87; acid val., 5.2; Polenske val., 0.25; R.M. val., 1.12; Hehner val., 94.7; and unsapon. matter, 1.11%. The fatty acid composition is as follows: palmitic, 8.8; stearic, 13.3; behenic, 7.9; oleic, 30.6; and linoleic acid, 39.4%. A sitosterol is also present (Paranjpe, J. Indian chem. Soc., 1931, 8, 767).

P. roxburghii G. Don syn. *P. javanica* (Lam.) Merrill; *Mimosa biglobosa* Roxb. non Jacq.

Fl. Br. Ind., II, 289.

ASSAM—*Khorial*, *zongto*, *yongchak*, *aoelgap*, *unkampinchang*.

A medium-sized to tall handsome tree found in Assam; it is also sometimes cultivated in gardens. Bark light grey to brown, rough; leaves large, bipinnate, with numerous small curved leaflets; flowers in dense turbinate or clavate heads hanging on long peduncles, small, yellowish; pods up to 50 cm. long, dark brown, smooth; seeds large, many. This species has been confused in the past with the African *P. biglobosa* (Jacq.) Benth., which is, however, distinct.

The tender pods are eaten; in Malaya, they are

used as a flavouring in food. The seeds, though slightly bitter, are eaten after roasting. In Malaya, pods and seeds are valued in medicine and are used in different ways, both externally and internally, for stomach disorders. Pods pounded in water are also used for washing the head and the face. Bark and the leaves are employed in making lotions for skin diseases and ulcers. Bark, leaves and roots are reported to be cyanophoric (Fl. Assam, II, 151; Burkill, II, 1670; Fox, Philipp. J. Sci., 1952, 81, 330; Quisumbing, 1034).

The tree yields a pale yellow wood, which is soft, light (wt., 417–81 kg./cu.m.), straight- or shallowly interlocked-grained and moderately coarse or even-textured; it has an unpleasant garlic-like odour when green which, however, disappears soon. The wood seasons well but is not durable in exposed situations or in contact with the ground; it is subject to infestation by blue stain and by powder-post beetles. It is easy to saw and peel and can be worked to a good finish. The wood is used in Malaya and Philippines for temporary constructions, boxes, shoes, washbowls and other utensils. It is a good fuelwood, burning slowly and completely. It has also been tried as a source of paper pulp (av. length of ultimate fibre, 1.15 mm.; diam., 0.029 mm.). Analysis of the wood gave (dry basis): lignin, 26.0; holocellulose, 63.7; pentosans, 18.9; silica, 1.4; and ash, 2.5% (Browne, 235; Burkill, II, 1670; Brown, I, 423–24; Monsalud & Nicolas, Philipp. J. Sci., 1958, 87, 119).

The bark (tannins, 6–20%) is reported to be suitable for tanning; it is used for dyeing nets in Philippines [Edwards *et al.*, Indian For. Rec., N.S., Chem. & Minor For. Prod., 1952, 1(2), 153; Brown, 1941, II, 136; Burkill, II, 1671].

PARKINSONIA Linn. (*Leguminosae*; *Caesalpiniaceae*)

A small genus of trees and shrubs distributed in the warmer parts of America and Africa. One species has been introduced and become naturalized in India.

P. aculeata Linn.

D.E.P., VI(1), 110; Fl. Br. Ind., II, 260.

HINDI—*Vilayati kikar*, *vilayati babul*; BENG.—*Balati kikar*; MAR.—*Adanti*; GUJ.—*Pardeshi baval*, *ram baval*; TEL.—*Sima tumma*.

A large spinous shrub or a small tree, native of tropical America, found almost throughout the drier parts of India. Bark green or brown, thin, smooth; leaves bipinnate, ending in a stout spine; pinnae 1–3

PARKINSONIA

pairs, 15–30 cm. long, pinnules ovate or oblanceolate, minute; flowers in lax axillary racemes, yellow, fragrant; pods slender, moniliform, up to 10 cm. long; seeds usually 4–7, oblong, smooth dark brown, mottled.

The plant is frequently grown for its showy flowers and also as a hedge. It has a fast rate of growth and with careful pruning and training is very suitable for the purpose. It is useful for reafforestation and particularly in the outer rows of arid zone shelter belts. Propagation may be done by seeds, transplants and roots or shoot cuttings [Katyal, *Indian Fmg.*, N.S., 1955–56, 5(12), 39; Bor. 72; Prakash, *Indian For.*, 1958, 84, 334].

Young branches are lopped for feeding goats and sheep which readily eat even fallen leaves. Analysis of the fallen leaves gave the following values (dry basis): protein, 7.5; ether extr., 1.8; N-free extr., 44.8; fibre, 29.0; ash, 16.9; calcium, 4.16; and phosphorus, 0.17%. All parts of the plant are reported to be used as antipyretic; the leaves are considered diaphoretic and abortifacient. Presence of alkaloids and steroids is indicated in leaves, stems and flowers (*Jt Publ. imp. agric. Bur.*, No. 10, 1947, 12, 208; Hocking, 162; Webb, *Bull. sci. industr. Res. Org. Aust.*, No. 268, 1952, 54; Simes *et al.*, *ibid.*, No. 281, 1959, 15).

The seeds (wt., 7.5 g./100) are edible and contain albumin and glutelin as the principal proteins. They contain c. 28% of mucilage (protein-free basis). Seeds also yield 1.65% of a golden coloured fatty oil having the following characteristics: n^{20} , 1.4719; sap. val., 190.6; iod. val., 114.0; thiocyanogen val., 69.1; Hehner val., 96.3; and unsapon. matter, 6.25%. The component fatty acids of the oil are: saturated, 23.4; oleic, 20.6; and linoleic, 56% (Hocking, 162; *Chem. Abstr.*, 1933, 27, 1027; Tookey *et al.*, *J. agric. Ed Chem.*, 1962, 10, 131; Grindley, *J. Soc. chem. Ind., Lond.*, 1946, 65, 118).

The wood is white to purplish brown in colour, close-grained, hard and heavy (wt., 833 kg./cu.m.). It is used as fuel and makes good charcoal. The bark yields a beautiful white but short and brittle fibre, suitable for mixing with other pulps in paper making (Gamble, 270).

PARMENTIERA DC. (*Bignoniaceae*)

Chittenden, III, 1485; Benthall, 344, Fig.

A very small genus of shrubs or small trees distributed in Mexico and Panama. One species, *P. cereifera* Seem. (CANDLE TREE), a native of Panama is

grown in Indian gardens for its ornamental candle-like fruits.

It is a small spreading tree with trifoliolate leaves and greenish white flowers, c. 5.0 cm. long, borne on the trunk and branches. The fruits are long (50 cm. \times 1.7 cm.), cylindrical, smooth, waxy yellowish or white, resembling candles. They are fleshy and said to be eaten in Panama; they are also fed to cattle. The leaves contain an unidentified glycoside. Fruits, leaves and roots contain traces of hydrocyanic acid (Benthall, 346; Williams & Williams, 247; Wehmer, II, 1137; Quisumbing, 1046).

PARNASSIA Linn. (*Saxifragaceae*)

A genus of hardy perennial herbs distributed in North temperate and arctic regions, extending south to the mountains of India. About a dozen species occur in India.

P. palustris Linn.

Fl. Br. Ind., II, 401; *Blatter*, I, 126.

A delicate herb with short, erect rootstock found in Kashmir (Baltistan) at an altitude of 2,250 m. Leaves radical, stalked, heart-shaped; flowers large, white or cream; capsules oblong-elliptic, many-seeded.

The plant can be propagated by seed or division of rootstock, the flowers dye aluminium-mordanted cotton dull yellow. The herb contains tannin, and is used as astringent. A decoction of the plant is used as a sedative in nervous palpitations and epileptic convulsions (Perkin & Everest, 636; Hoppe, 643; Steinmetz, II, 332; Hocking, 162).

Parrotia — see *Parrotiopsis*

PARROTIOPSIS Schneid. (*Hamamelidaceae*)

A monotypic genus distributed in N. W. Himalayas.

P. jacquemontiana (Decne) Rehd. syn. *Parrotia jacquemontiana* Decne

D.E.P., VI (1), 111; *Fl. Br. Ind.*, II, 426.

N. W. HIMALAYAS—*Paser, pishor, pahu, killar, sha*.

A large deciduous shrub or a small tree, up to 7 m. high, found in the N. W. Himalayas from Yamuna westward, at altitudes of 900–2,700 m. Bark thin, grey, smooth; leaves sub-orbicular or broadly obovate, crenate; flowers greenish white in ovoid heads; capsules minute, woody; seeds ellipsoid, brownish, shining.

The plant can stand a certain amount of shade and

usually occurs gregariously as an underwood in deodar, pine and other forests, suppressing their natural regeneration, as it coppices very vigorously. It is a good soil improver. The rate of growth is reported to be slow with an annual girth increment of 0.99–1.33 cm. (Troup, II, 496; Gamble, 331).

The wood, mostly constituted by the sapwood (heartwood is blackish grey, narrow, sometimes absent in small billets), is straight-grained, even- and fine-textured, hard, strong, elastic and heavy (av. wt., 849 kg./cu.m.). It can be easily air-seasoned in billets if stacked under cover with the ends coated with a moisture-retardant paint; it can also be kiln-seasoned under mild conditions. The wood is not durable and offers poor resistance against white ants and fungi. It is easy to saw, work and turn, and finishes to a smooth surface which takes a fine polish (Chowdhury, *Indian For. Bull.*, N.S., No. 84, 1934, 66; Trotter, 1944, 143; Purushotham *et al.*, *Indian For.*, 1953, 79, 49).

Parrotiopsis wood is valued locally for walking sticks, tent pegs, rice pestles, cots, carving, toys, turnery work and as firewood. It is suitable for tool handles, textile mill shuttles, fishing rods, mathematical instruments and agricultural implements (Trotter, 1944, 144, 214, 226; Chowdhury, loc. cit.; Coventry, II, 48; Rehman & Lal, *Indian For. Bull.*,

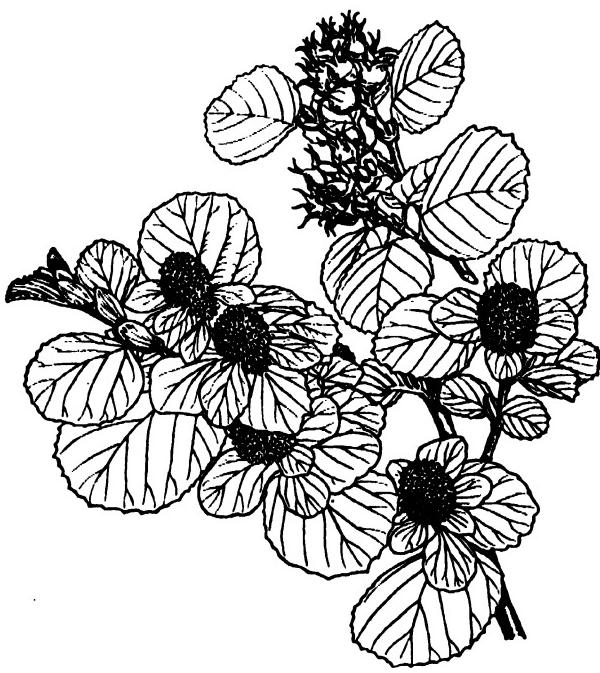
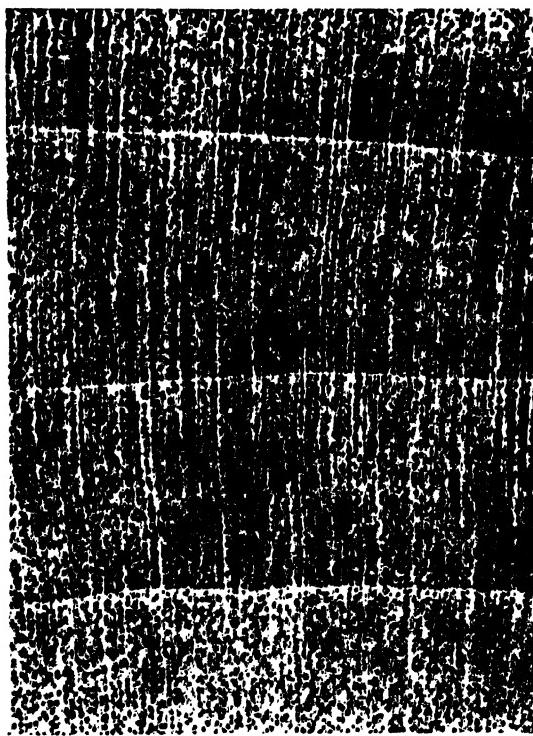


FIG. 114—PARROTIOPSIS JACQUEMONTIANA—FLOWERING AND FRUITING BRANCHES



F.R.I., Dehra Dun. Photo : S. S. Ghosh

FIG. 115—PARROTIOPSIS JACQUEMONTIANA—TRANSVERSE SECTION OF WOOD ($\times 10$)

N.S., No. 121, 1943, 1; *Indian For.*, 1952, 78, 369; Simmonds, *Kew Bull.*, 1956, 135; Sekhar & Bhartari, *Indian For.*, 1962, 88, 226).

The tough and flexible twigs of the plant are used for tying loads, constructing rope or twig bridges and for basket making and other wicker work. The leaves are reported to provide a poor quality fodder for goats and cattle (Gamble, 331; Laurie, *Indian For. Leaf.*, No. 82, 1945, 15).

Parsley — see *Petroselinum*

Parsnip — see *Pastinaca*

PARSONSIA R. Br. (*Apocynaceae*)

Fl. Br. Ind., III, 650.

A genus of twining shrubs distributed in tropical Asia, Australia, Polynesia and New Zealand. One species occurs in India.

P. helicandra Hook. & Arn. syn. *P. spiralis* Wall. (MAL.—*Penalivalli*; BOMBAY—*Nagal kuda*) is an evergreen twiner with elliptic, ovate-oblong or oblong-lanceolate leaves and white, greenish or yellowish flowers found in the evergreen forests of Khasi hills

PARSONSIA

(1,600 m.). Sundarbans, Orissa, Madras, western ghats from Konkan southwards and along the backwaters in Kerala.

The juice of the plant is given internally in insanity (Kirt. & Basu, II, 1578).

PARTHENIUM Linn. (*Compositae*)

Rao, *J. Bombay Nat. Hist. Soc.*, 1956-57, **54**, 218.

A small genus of herbs or shrubs distributed in America.

P. hysterophorus Linn., a herb c. 1.0 m. in height, occurs as an exotic weed in Poona in Maharashtra State; in some places it has become noxious. Stem longitudinally grooved; leaves irregularly dissected, pubescent; flowerheads terminal or axillary, c. 5 mm. in diam., white; fruits broadly obovoid, dark brown.

In its native habitat, the plant is reported to be used as a tonic, febrifuge, emmenagogue and as an analgesic in neuralgia; a decoction of the root is given in dysentery. A bitter glycoside, parthenin (parthenicin, m.p. 168-69°), and unidentified alkaloids have been reported from the herb (Hocking, 162; Uphof, 267; U.S.D., 1947, 1544; Merck Index, 774).

PARTHENOCISSUS Planch. (*Vitaceae*)

D.E.P., VI (4), 253; Fl. Br. Ind., I, 655.

A small genus of climbing shrubs distributed from India to Indo-China, China and Japan, and in North America. Three species occur in India.

P. himalayana (Royle) Planch. syn. *Vitis himalayana* Brandis; M. Laws. (Fl. Br. Ind.) in part (N. W. HIMALAYAS—*Phlankar, zemaro*; JAUNSAR—*Kandur*; GARIWAL—*Philuna*; KUMAUN—*Chappar tang, laderi*; NEPAL—*Charchare*; LEPCHA—*Illotagbret*) is a large woody climber with stems, up to 30 m. in height and 15 cm. in diam., trifoliolate leaves, small yellowish green flowers and pea-sized black berries found throughout the Himalayas between 900-3,300 m. and in Kashi, Naga and N. Cachar hills between 600-1,950 m. The plant which is characterized by the beautiful yellow, orange and red tints of its leaves in autumn often covers the tall trees in temperate Himalayas and is destructive to them. The wood (wt., 529-833 kg./cu.m.) is dark brown, hard and strong. It has a pretty silver-grain, but requires long seasoning. It is suitable for picture frames and such other purposes. The young vines are used as natural cords to tie the bundles of grass. Berries are edible. Leaves are used as fodder (Gamble, 190; Fl. Assam, I, 296; Cowan & Cowan, 38).



FIG. 116—PARTHENOCISSUS HIMALAYANA—FLOWERING BRANCH

P. semicordata (Wall.) Planch. syn. *Vitis himalayana* var. *semicordata* M. Laws. (Fl. Br. Ind.) has almost the same distribution as *P. himalayana*. *P. neilgherriensis* (Wight) Planch. syn. *Vitis himalayana* M. Laws. (Fl. Br. Ind.) in part, non Brandis; *V. anamalayana* Bedd. is found in the western ghats from Nilgiris to Anaimalai and Palni hills up to 1,800 m. Both these species are closely related to *P. himalayana* and may not be distinguished from it in economic uses.

Partridges—see Birds

Pasania—see *Lithocarpus*

PASPALIDIUM Stapf (*Gramineae*)

A small genus of perennial semi-aquatic or terrestrial grasses distributed in the warm countries of the world. Three species occur in India.

P. flavidum (Retz.) A. Camus syn. *Panicum flavidum* Retz.

Bor, *Indian For. Rec.*, N.S., Bot., 1940, **2**, 172, Pl. 44. GUJ.—*Jhinko samo*; TEL.—*Udagaddi, neetichama*; TAM.—*Arisipilli*; ORIYA—*Bilainangi*.

UTTAR PRADESH—*Matamar, chapri*.

An annual grass with an erect slender stem, 0.3-1.2 m. long, ascending from a short decumbent base, linear lanceolate leaves, 7.5-15 cm. long, and a panicle of 6-9 or even fewer sessile spikes in two rows on a flattened rachis. It is found distributed over the whole of India. It is said to be a very common grass growing in the bunds of paddy fields



FIG. 117—PASPALIDIUM FLAVIDUM

and in wet situations and going up to moderate elevations on the hills. The grass is considered to be an excellent fodder and the grain is collected and eaten in times of want. The leaves and roots are said to be slightly cyanogenic (Ranga Achariyar, 69 : Blatter & McCann, 141 : Quisumbing, 1023).

P. geminatum (Forsk.) Stapf syn. *Panicum paspaloides* Pers. and *P. punctatum* (Burm.) A. Camus syn. *Panicum punctatum* Burm., *P. mucronatum* Roth. are two other species found occurring more or less throughout India. They are also considered useful as fodder (Dalziel, 535 ; Burkill, II, 1673 ; Bor, 1960, 332).

PASPALUM Linn. (Gramineae)

A large genus of grasses distributed in the warmer parts of both hemispheres, but more abundantly in S. America. About 14 species are recorded in India,

of which one is widely cultivated for its grains and for fodder.

P. conjugatum Bergius BUFFALO GRASS Fl. Assam, V, 255 ; Hitchcock, 615, Fig. 892.

An annual or perennial stoloniferous grass, with culms 20–60 cm. long, recorded in Assam, Bengal, Mysore and Kerala. Culms erect ; leaf blades 5–20 cm. long and 6–12 mm. broad, soft, covered with scattered hairs ; inflorescence 7.5–12 cm. long, with spikelets 2-seriate deciduous.

This grass is common in the hotter tropical parts of America and Africa and is suspected to be an adventive in Asia. It is reported often to become a pest in tea and other forest plantations, but furnishes a valuable fodder much liked by cattle. The grass should be grazed when young, since in older stages, the seeds tend to stick inside the throats of livestock and choke them. The grass can also be used for making lawn (Bor, 1960, 336 : Burkill, II, 1673 : Whyte *et al.*, 1959, 353).

Composition of the grass, cut before flowering showed : moisture, 78.7 ; protein, 2.9 ; fat, 0.4 ; carbohydrates, 9.5 ; fibre, 5.6 ; mineral matter, 2.9 ; calcium, 0.092 ; phosphorus, 0.043 ; dig. protein, 1.6% ; and nutritive ratio, 6.1. It contains appreciable amounts of carotene and ascorbic acid (Teik, *Sci. Ser., Dep. Agric., Malaya*, No. 24, 1951, 19, 69, 78, 84).

Administration of a 5% infusion of the plant by subcutaneous injections to rabbits (0.5–1 c.c./kg. body wt.) reduces the blood coagulation time of the animals by 50% in 3–4 hours. The plant owes its haemostatic action to the presence of a glucoside paspaloside (m.p. 274.6°), which on hydrolysis yields glucose and hiteolin (5,7,3',4'-tetrahydroxyflavone). The glucoside depresses the isolated intestines of rabbits in 1:50,000 dilution and also increases capillary resistance, though not to a marked extent (*Chem. Abstr.*, 1953, 47, 12639).

P. dilatatum Poir. DALLIS GRASS

Fl. Assam, V, 256 ; Hitchcock, 615, Fig. 893.

A strongly tufted perennial grass, native of S. America, introduced into India and now fairly well established as a pasture grass in all hill stations. Culms 50–150 cm. high, developing from a thick root-stock ; leaves bluish green, 30–60 cm. long and 5–15 mm. wide ; inflorescence 5–10 cm. long.

This grass is best adapted to a humid sub-tropical climate with not less than 88–100 cm. of rain ; it is said to be winter hardy. It thrives best on moist

PASPALUM

heavy soils. It has been successfully established in Assam, flourishing in some areas at elevations of 900-1,500 m., with an average annual rainfall of about 280 cm. Under protected conditions it is said to yield c. 14,000 kg. of green grass per hectare in several cuttings [Bor, 1960, 338; Whyte *et al.*, 1959, 353; Paul, *Indian Fmg.*, N.S., 1953-54, 3(3), 12].

The grass can be propagated by seed (9-14 kg./ha.) or rooted slips; it withstands close grazing and trampling and produces a high proportion of leafy growth. It should not be allowed to grow more than 20-30 cm., as it becomes coarse and relatively unpalatable when mature. The grass is said to produce abundant seeds, but seed production may be seriously reduced by ergot (Whyte *et al.*, 1959, 353; Gandhi, *Indian J. agric. Sci.*, 1957, 27, 131).

P. dilatatum yields nutritious forage which may be fed green, or made into silage and hay. Analysis of the pasture grass gave: moisture, 75.0; protein, 3.0; fat, 0.6; N-free extr., 11.0; fibre, 7.2; and mineral matter, 3.2%; calcium, 140; phosphorus, 50; potassium, 430; magnesium, 100; and iron, 4 mg./100 g.; dig. protein, 2.2%; total dig. nutrients, 16.0%; and nutritive ratio, 6.3. Dallis grass is a good source of carotene (up to 464 p.p.m.) and ascorbic acid; it contains iodine (320 µg./kg., dry wt. basis). The early cut hay from Assam contains (dry wt. basis): protein, 9.4; calcium, 0.45; and phosphorus, 0.19% (Paul, loc. cit.; Morrison, 375, 1024, 1098; Iodine Content of Foods, 107; Teik, *Sci. Ser., Dep. Agric., Malaya*, No. 24, 1951, 84; *Chem. Abstr.*, 1948, 42, 7460).

Due to its strong rooting habits it is recommended as a suitable grass for control of soil erosion (Gandhi, loc. cit.).

A species of ergot, *Claviceps paspali* Stevens & Hall is reported to infect its heads and cases of cattle being poisoned after feeding on infected heads have been recorded from Australia, New Zealand and S. Africa. The toxicity varies with the stage of the development; it is most poisonous when the ergots are being formed, while mature ergots are less toxic. The ergot causes a condition described as 'paspalum staggers', the symptoms being not unlike those following feeding on the wild form of *P. scrobiculatum* (Watt & Breyer-Brandwijk, 1094; Gardner & Bennetts, 2).

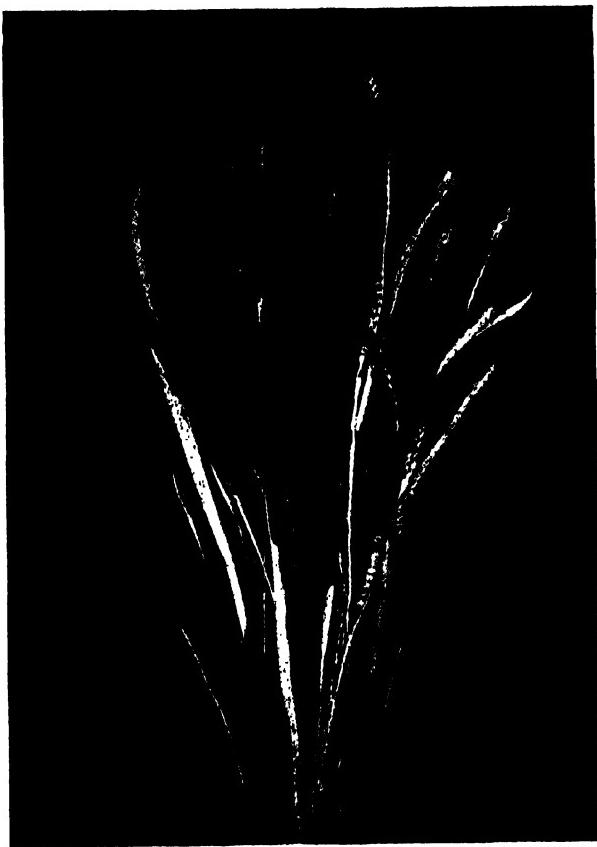
P. scrobiculatum Linn. syn. *P. commersonii* Lam.; *P. scrobiculatum* var. *commersonii* Stapf; *P. scrobiculatum* var. *frumentaceum* Stapf KODO MILLET

D.E.P., VI(1), 111; C.P., 868; Fl. Br. Ind., VII, 10 in part; Bor, *Indian For. Rec., N.S., Bot.*, 1941, 2(1), 174, Pl. 45.

HINDI—*Kodo, kodra*; BENG.—*Kodoa dhan*; MAR.—*Kodra, harik*; GUJ.—*Kodro, menya*; TEL.—*Arikalu, allu, arugu*; TAM. & MAL.—*Varagu*; KAN.—*Haraka*; ORIYA—*Kodus*.

An annual grass found sometimes wild but mostly cultivated almost throughout India. Culms up to 90 cm. high, often tufted, with a very short rhizome, leafy from the base upwards; leaves two ranked, stiff and erect, 15-45 cm. x 2-8 mm.; inflorescence of two or more sessile alternate spikes.

Some authors consider *P. scrobiculatum* var. *commersonii* Stapf, which includes the wild forms, as a separate species. The wild forms are said to be short-lived perennials, unlike the cultivated forms which are annuals. In the latter, the whole plant as well as the individual spikelets grow to a larger size than in the wild forms. The wild form is found



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FIG. 118—PASPALUM SCROBICULATUM—FRUITING PANICLES

throughout India ascending the hills up to 1,600 m. It is considered probably indigenous to S. Africa. It thrives in moist places and is grazed by cattle, especially buffaloes (Bor, 1960, 335; Meredith, 387; Blatter & McCann, 136; Whyte *et al.*, 1959, 355; Burkhill, II, 1674).

Kodo millet is a minor grain crop grown throughout India, but to a greater extent in the Deccan and S. India (Madras, 248,800 ha.; Andhra Pradesh, 222,120 ha.; Gujarat & Maharashtra, 157,800 ha.) than in the north; but figures are not available for all the States; generally the data are included along with those of *Panicum miliaceum* and *Panicum miliare* under Small Millets (cf. *Panicum*). In Andhra Pradesh, Nellore, Kurnool, Anantapur and Mahaboobnagar districts are the chief areas, while in Madras, the major areas are in Tiruchchirappalli, S. Arcot and Ramanathapuram districts. In Gujarat, it is a very important crop in the *goradu* soils of Kaira district and alluvial soils of Panch Mahals. In Maharashtra, Ratnagiri district accounts for the largest area (Majumdar & Khunte, *Poona agric. Coll. Mag.*, 1955-56, 46, 183; Mudaliar, 178; Solomon, *Bull. Dep. Agric. Bombay*, No. 186, 1951, 43).

Several types are under cultivation, differing in such characters as crop duration (early, medium or late maturing), growth habit (tall or short), panicle characters, arrangement of the grain in two to four or five rows, and grain characteristics (light red coloured grains with sweet taste or dark grey grains with bitter taste). In Gujarat, four distinct variants are recognized based on the shape of the panicle. They are: (a) *Haria* (2-rowed), (b) *Choudharia* (3-4-rowed), (c) *Kodra* (4-5-rowed), and (d) *Haria choudharia*. Two improved strains 494-1 and 80-2 isolated as straight line selections from the local population have shown 12-16% higher yield. Some high yielding strains are reported also from Madras, Mysore, Madhya Pradesh and Uttar Pradesh (Yegna Narayan Aiyer, 100; Roberts & Kartar Singh, 284; Majumdar & Khunte, loc. cit.; *Mem. Dep. Agric. Madras*, No. 36, 1954, 175; *Agric. & Anim. Husb. Res.*, Indian Coun. agric. Res., 1929-46, pt II, 1952, 43; *Annu. Rep. Indian Coun. agric. Res.*, 1952-53, 30).

Kodo millet is a hardy, drought resistant crop which thrives well in conditions of moderate rainfall, ranging between 25 and 75 cm. It can be grown on a variety of soils, but thrives best on loamy soils, though it is relegated generally to poor gravelly or stony soils in Deccan and S. India, while in Gujarat it is said to be grown often on *goradu* (rice alluvial)

soils. It is said to resist alkalinity to a remarkable extent (Majumdar & Khunte, loc. cit.; Solomon, loc. cit.; Mudaliar, 178-79).

Seeds are sown broadcast or drilled in June-July at 12.5-25 kg./ha., either as a pure crop or mixed with *tur* in Mysore and Madras or with *tur* and sesamum with a sprinkling of *ambadi* in Bombay. In low lying damp fields in Gujarat, it may be grown mixed with rice in unembanked fields. The crop raised by transplanting seedlings in their third week is said to have given better results than crop raised by direct sowing, grain yield being 63% more over control. In most of the cultivated types the plants develop a deep purple pigmentation as they grow and at a later stage the field has a characteristic violet look. The panicles never emerge fully and the crop is highly cleistogamous. Seed setting is reported to be more or less completely dependent on weather conditions (Yegna Narayan Aiyer, 101; Mudaliar, 178-79; Solomon, loc. cit.; Naidu & Rao, *Andhra agric. J.*, 1959, 6, 76; *Mem. Dep. Agric. Madras*, No. 36, 1954, 174-75; Youngman & Roy, *Agric. J. India*, 1923, 18, 580).

Kodo millet is said to be very hardy and singularly free from pests and diseases. A smut caused by *Sorosporium paspali* McAlpine and a rust caused by *Uredo paspali-sorobiculati* Syd., are reported, but both are said to be rare and insignificant. A species of *Striga* is reported to cause serious loss in Kurnool district (Yegna Narayan Aiyer, 102; *Indian J. agric. Sci.*, 1950, 20, 107).

The crop comes to maturity in about 4-6 months after sowing. The yield of grain per hectare varies from area to area. Average yields reported are: 825 kg./ha. in Andhra Pradesh, 1,030 kg./ha. in Madras, and 250-500 kg./ha. in Mysore; heavier yields are reported from black soils, and in Baroda. Some good selections in Bombay and Madhya Pradesh have given yields up to 1,250 kg./ha. (Yegna Narayan Aiyer, 100-02; Mudaliar, 179; Govande, *Indian Fmg*, 1950, 11, 153).

The grain which has a hard horny persistent husk (40% by weight of grain), is smeared with red earth and dried in the sun and then husked to obtain its edible part, which is white in colour. The grain should be well matured and stored for 6 months before use as food, as immature or newly gathered grains are reported to be poisonous. The grain is cooked like rice and is also used for preparing a kind of bread. It is recommended for diabetic persons as

a substitute for rice (Yegna Narayan Aiyer, 101; Mudaliar, 179).

Analyses of the whole and husked grains gave the following values: *whole grain*—moisture, 11.6; protein, 10.6; fat (ether extr.), 4.2; carbohydrates, 59.2; fibre, 10.0; and mineral matter, 4.4%; calcium, 49.5 mg.; phosphorus, 284.0 mg.; iron, 6.0 mg.; and thiamine, 400 $\mu\text{g.}/100 \text{ g.}$; *husked grain*—moisture, 11.7; protein, 11.6; fat (ether extr.), 1.3; carbohydrates, 74.0; fibre, 0.4; and mineral matter, 1.0%; calcium, 35.0 mg.; phosphorus, 121.0 mg.; iron, 1.7 mg.; and thiamine, 150 $\mu\text{g.}/100 \text{ g.}$. The grains also contain riboflavin (27 $\mu\text{g.}/100 \text{ g.}$) and nicotinic acid (0.4 mg./100 g.). The starch from the grains consists of 32.1% of amylose and 67.9% of amylopectin (Kadkol *et al.*, *J. sci. industr. Res.*, 1954, **13B**, 744; *Rep. Dep. Nutr. Govt. Bombay*, 1957, 23; Patel *et al.*, *Sci. & Cult.*, 1958-59, **24**, 291).

The biological value of the proteins of kodo millet is 57%. The essential amino acids present in the proteins are: arginine, 4.80; histidine, 2.01; isoleucine, 7.73; leucine, 10.66; lysine, 3.31; methionine, 3.16; phenylalanine, 9.13; threonine, 3.75; tryptophan, 0.73; and valine, 7.25 g./16 g. N. Lysine is the limiting amino acid. Feeding experiments with rats indicate that kodo proteins can replace a part of rice proteins without affecting the biological value of the latter. In its overall nutritive value, kodo is reported to be inferior to wheat (Ramachandran & Phansalkar, *Indian J. med. Res.*, 1956, **44**, 501; Kundaji & Rao, *Curr. Sci.*, 1954, **23**, 93; Kadkol *et al.*, loc. cit.).

The grains have often been reported to cause poisoning of men and animals when used as food and occurrence of non-poisonous, as distinct from poisonous, types has been reported from Madras. Grains from certain localities and stagnant areas are also said to be poisonous. It is stated that the grain and straw become poisonous when the reaped crop is left unstacked in the field in rainy and wet conditions. In Madras, it has been recorded that a herd of 13 wild elephants which raided a field and fed on the ripening crop, became sick and 11 of them died within the day, while 2 more died in the course of the next 2-3 days. Newly harvested grain also is said to be powerfully narcotic, but is said to be eaten by the poor people, who by repeated use are supposed to have become immune to its effect. By a process of macerating the grains for sometime with water and cow-dung, the light and hollow immature grains, considered more injurious, are discarded as they float up. Storage of the grains over a number of years is

said to diminish the poisonous properties; so also grains eaten along with whey are said to be neutralized of the poison (Ayyar & Narayanaswamy, *Curr. Sci.*, 1948, **17**, 367; *Mem. Dep. Agric. Madras*, No. 36, 1954, 174; *Indian For.*, 1934, **60**, 570; Solomon, loc. cit.).

The poisonous nature of the grains is said to be located to a large extent in the outer coat or husk and a fungus is said to be almost invariably present there. The chief symptoms of *kodra* poisoning are unconsciousness, delirium with violent tremors of the voluntary muscles, vomiting (in the case of human beings) and difficulty in swallowing. The antidotes usually used are gruel made of *urd* (*Phaseolus mungo*) flour, juice of the banana stem, the astringent juice of the guava or the leaves of *Nyctanthes arbortristis*, tamarind water and buttermilk (Burkill, II, 1675; *Indian For.*, 1934, **60**, 570).

The toxic principle is extracted along with the fatty oil present in the grains, when the latter are treated with petroleum ether; the defatted residue is non-toxic. The extracted fat (m.p. 42° ; n^{20}_{D} , 1.4650; iod. val., 93.6; sap. val., 170.7), when injected intramuscularly in a dose of 1 g., causes death of dogs and monkeys; crows appear to be particularly susceptible to it when ingested orally or intramuscularly. The toxic principle is destroyed when the fat is treated with an acid or alkali. A method has been developed to distinguish poisonous from non-poisonous varieties; the fat from the former gives a red colour on addition of concentrated sulphuric acid, whereas the innocuous grains yield a fat which does not respond to the colour test (Ayyar & Narayanaswamy, *Nature, Lond.*, 1949, **163**, 912).

The grain husk after grinding is sometimes used as feed; it contains: moisture, 10.6; protein, 4.9; fat (ether extr.), 3.3; carbohydrates, 71.1; fibre, 2.2; and total ash, 8.0% (Sen, *Bull. agric. Res. Inst. Pusa*, No. 70, 1917, 44).

The young grass is readily eaten by cattle. The wild form, *P. scrobiculatum* var. *commersonii*, is grown for pasture and hay in Queensland, where it is reported to be non-poisonous to stock; it contains (dry wt. basis): protein, c. 5; fibre, 32.5; total ash, 9.8; calcium, 0.32; and phosphorus, 0.23%; starch equivalent, 60. Carotene is present in appreciable amounts (Webb, *Bull. Coun. sci. industr. Res. Aust.*, No. 232, 1948, 63; Paltridge, *Bull. sci. industr. Res. Org. Aust.*, No. 274, 1955, 16, 20, 32, 37).

The straw is considered to be a good cattle fodder in some parts of India but in most parts it is either

poor, unsuitable or harmful and hence used for manuring or roofing. In Madras, it is used as a manure for alkaline soils. Analysis of the straw gave: moisture, 9.2 ; protein, 2.2 ; fat, 3.2 ; carbohydrates, 44.3 ; fibre, 29.7 ; and ash, 11.0% (Bor, *Indian For. Rec.*, N.S., *Bot.*, 1940, 2, 175 ; Solomon, *Bull. Dep. Agric. Bombay*, No. 186, 1951, 44 ; Mudaliar, 178 ; Ramiah, *Bull. Dep. Agric. Madras*, No. 33, 1941, 12).

A decoction of the roots and rhizomes is reported to be used in the Philippines as an alterative in child-birth and the juice expressed from the stem is said to be useful for corneal opacity (Quisumbing, 105).

Three other species of *Paspalum* occurring in India are of fodder value. Of these *P. distichum* Linn., found nearly throughout tropical parts of India growing in wet places and moist soils, is said to be a useful soil binder and valuable pasture grass ; *P. orbiculare* Forest, syn. *P. scrobiculatum* Linn. (*Fl. Br. Ind.* in part) is found in Assam and Madras and is a hardy perennial grass useful as fodder, though reported to possess some poisonous effect ; and *P. vaginatum* Sw. is a perennial grass with creeping rhizomes found mostly on the sandy costs of Maharashtra, Gujarat

and Madras, where it acts as an efficient sand binder ; it is salt tolerant and furnishes some forage [Bor, 1960, 339-41 ; Bharadwaja *et al.*, *Agra Univ. J. Res. (Sci.)*, 1956, 5, 285 ; Malik, *Indian Fmg. N.S.*, 1959-60, 9(4), 38 ; Blatter & McCann, 140 ; Whyte *et al.*, 1959, 356].

Three more species, mainly native of America, have been introduced into India and tried as fodder grasses. Of these, *P. notatum* Fluegge (BAHIA GRASS) is a slow growing, deep rooted perennial grass, native of Central and South America ; it has been found to remain green throughout the summer. It is reported to be drought resistant and considered valuable as a soil binder. Several geographical races and strains are known. It can be used for pasture, as it persists under grazing and transplanting. *P. plicatulum* Mich. is a tufted grass up to 100 cm. tall, native of tropical America, considered to be an important fodder grass in Brazil. It is reported to be slow growing, susceptible to frost and not setting seed satisfactorily. *P. urvillei* Steud., a perennial grass native of Uruguay and Argentina, introduced into many countries including India, has been tried as a pasture grass. It is taller and coarser than *P. dilatatum*, and reported to give good yields of fair hay (Bor, 1960, 339-41 ; Whyte *et al.*, 1959, 335-56 ; Meredith, 387).

Paspalum spp.—see *Digitaria*

PASSIFLORA Linn. (*Passifloraceae*)

A large genus of herbaceous or woody tendril climbers, mostly distributed in tropical and sub-tropical America, a few in tropical Asia, Australia and Polynesia. Only two species are found wild in India, while many others are introduced and have become naturalized. Many of the species are of ornamental value and a few are cultivated for their edible fruits.

P. edulis Sims PASSION FRUIT, PURPLE GRANADILLA
Chakravarty, *Bull. bot. Soc. Beng.*, 1949, 3, 61 : Bor & Raizada, 254, Pl. 93 & Fig. 148.

A woody climber, native of Brazil, now cultivated in all parts of the world, chiefly for its edible fruits and for its ornamental flowers. Leaves deeply 3-lobed, coarsely serrate ; flowers solitary, up to 7 cm. in diam., white, often tinted with purple ; fruit 4-5 cm. in diam., globose or ovoid, with a hard rind, enclosing an edible pulp and numerous small seeds. .

This plant has been introduced into India and is now reported to thrive well in Nilgiris (Coonoor),



FIG. 119—PASPALUM DISTICHUM

PASSIFLORA

Shevaroys and Wynnaad and to have done well in the Araku valley in Andhra Pradesh. It is found run wild in parts of Assam and Bengal and in areas near Ootacamund, Kodaikanal and Yercaud. In North India, it has been grown in Punjab, lower Kangra valley and near Mandi in Himachal Pradesh. The passion fruit is grown on a commercial scale in parts of S. Africa, Kenya, Australia, New Zealand and Hawaii [Sahadevan & Vijayan, *Indian Hort.*, 1956-57, 1(3), 25; Ramasomayajulu, *Andhra agric. J.*, 1955, 2, 310; Thapar, *Farm Bull. Indian Coun. agric. Res.*, No. 42, 1958, 1-16; Malan, *Fmg in S. Afr.*, 1953, 28, 407; Pruthi, *Advanc. Food Res.*, 1963, 12, 203-82].

P. edulis is said to include several forms. In addition to the common purple-fruited form (*P. edulis* f. *edulis*), a yellow-fruited form (*P. edulis* f. *flavicarpa*) had also been tried in this country. The purple-fruited form is reported to be suitable for higher elevations (900-1,800 m.), while at lower elevations it runs into leaf. The yellow-fruited form is said to thrive well at lower altitudes up to 450 m. and has been successfully grown in the lower elevations of Madras and Kerala. Hybrids between the purple and golden passion fruits are said to occur in North Queensland and they are reported to have a flavour and aroma intermediate to those of their parents (Thapar, loc. cit.; *Mem. Dep. Agric. Madras*, No. 36, 1954, 408; Naik, 354; Sahadevan & Vijayan, loc. cit.; Muthuswamy, *Madras agric. J.*, 1954, 41, 384; Levitt & McGillivray, *Agric. Gaz. N.S.W.*, 1958, 69, 518; Wills & Stephens, *Qd agric. J.*, 1954, 79, 205).

Passion fruit is said to thrive best in a warm, humid sub-tropical atmosphere, but with irrigation, gives profitable returns under less ideal conditions also. It can withstand light frosts, but heavy frosts are harmful. For passion fruit all soils are suitable except those which are heavy and poorly drained and of very low fertility. The vines can be grown on trellis, fence, bowers or pergolas; they can also be grown as intercrops, with such orchard trees as require 6-8 years to come to bearing. For this purpose the plants are set out at a spacing of 3-5 m. along low wire-trellises, constructed in between the rows of fruit trees. The vines may also be grown in a pure plantation with a spacing of 5-6 m. between the rows and about 3 m. apart in the row, depending upon the fertility of the land (du Preez, *Fmg in S. Afr.*, 1950, 25, 223; Muthuswamy, loc. cit.; Naik, 355; Levitt & McGillivray, loc. cit.; Wills & Stephens, loc. cit.).

Passion fruit is propagated either by seed or by semi-hard wood cuttings, 3-4 m. in length. Rooted



Photo : J. S. Pruthi, Nagpur

FIG. 120—PASSIFLORA EDULIS—FRUITING BRANCH

cuttings are said to come to bearing earlier than seedlings. Cuttings taken from well-matured wood strike root readily and can be transplanted in about three months. As passion fruit seeds lose viability with storage, they should be sown immediately after extraction, in seed pans or well-prepared nursery beds. They germinate in 2-3 weeks and the seedlings are ready to be set out in their permanent sites in 3-4 months' time, when they are about 15-25 cm. in height (Thapar, loc. cit.; Muthuswamy, loc. cit.; Naik, 355; Pruthi & Lal, *Indian J. Hort.*, 1954, 11, 138; Levitt & McGillivray, loc. cit.; Wills & Stephens, loc. cit.).

The vines may be manured once a year with well-rotted compost or cattle manure and a little of chemical fertilizers. Application of farmyard manure along with a mixture of ammonium sulphate, superphosphate and potassium sulphate in the ratio, 10:6:10 is said to have given good results in other countries (Muthuswamy, loc. cit.; Levitt & McGillivray, loc. cit.; Wills & Stephens, loc. cit.).

Pruning is not generally practised in S. India, but as the fruits are borne on new wood, pruning of diseased and overcrowded vines, up to the main branches, during February–March is recommended, to secure a good crop. In Australia regular pruning makes the vines bear a crop at different periods, but in S. Africa pruning is reported not to have been economical; in Ceylon two-node pruning gave significant increases in yield over no-pruning or other methods of pruning [Muthuswamy, loc. cit.; Thapar, loc. cit.; Naik, 355; Sahadevan & Vijayan, loc. cit.; Wills, *Qd agric. J.*, 1948, 66, 325; *Indian J. Hort.*, 1950, 7(3 & 4), 46; Buell, *Trop. Agriculturist*, 1955, 111, 18].

No serious pests or diseases of the passion fruit have been reported in India. Among the important diseases reported elsewhere are a mosaic disease, a bacterial disease caused by *Phytomonas passiflorae* Young, a brown spot caused by *Colletotrichum passiflorae* Stevens and a wilt caused by *Fusarium* sp. Among insect pests, the most important are fruit flies, fruit mites and a passion fruit bug (Pruthi, *Advanc. Food Res.*, 1963, 12, 203–82).

Seedling plants normally commence to bear in the second year of planting, reaching maximum yields in the sixth year; cuttings come to bearing much earlier sometimes producing precocious types. Maximum bearing of about 6.8–9 kg. (150–250 fruits) per plant is reached by about the sixth year. The yellow-fruited form may have to be artificially pollinated in some places where the natural fruit set is poor, but the vines are said to fruit reasonably well, if they are allowed to grow naturally over tall trees. Hand pollinated flowers are reported to have yielded larger fruits and a high correlation is said to exist between fruit size and quality and the number of pollen grains placed on the flower. The vines are in fruit almost throughout the year, but the bulk of the crop is harvested in two periods, once in May–June and again in September–October (Krishnamurthi, 116; Muthuswamy, loc. cit.; Wills & Stephens, *Qd agric. J.*, 1954, 79, 205; Naik, 355; *Men. Dep. Agric. Madras*, No. 36, 1954, 408; *Hort. Abstr.*, 1960, 30, 158; Pruthi & Lal, *Indian J. Hort.*, 1954, 11, 138).

As the ripe fruits fall off to the ground, well-coloured fruits should be harvested before they are dead ripe; some, however, prefer to let the fruits ripen well and fall to the ground before collecting them. Because of the hard rind or shell, the fruits withstand transport well (Naik, 355; Muthuswamy, loc. cit.).

Both the purple and the yellow fruits have a short storage life at room temperature; when kept long, the rind shrivels and the fruit becomes less attractive. The rate of respiration of purple passion fruit is found to vary markedly with season as well as with individual fruits; in fresh fruits, it ranged from 40 to 130 mg. CO₂/kg./hr. Under air storage at 20°, the fruits produced 370 µl. of ethylene/kg./hr. which is perhaps the highest among the fruits studied so far. The onset of ethylene production coincided with the onset of respiratory rise. The factors which influence the refrigerated storage of passion fruit include the stage of maturity at the time of picking, method of picking, time lag between harvest and storage, variety, and season. The optimum temperature for refrigerated storage of the fruit was found to be 42–45°F. (R.H. 85–90%) with a storage life of about 4–5 weeks. The loss of weight during storage of waxed fruit or fruit packed in polythene bags is said to be negligible (<5%). The fruits are liable to the attack of various fungi during storage. Dipping the fruits in dilute solutions of formaldehyde (2%), iodine (2%), boric acid (5%), and alcohol (95%) prior to storage, or storing the fruits in crates and polythene bags treated with 5% lysol or in crates lined with iodine (1–2% solution) impregnated paper scrap are reported to prevent the attack of these micro-organisms during the period of storage (Pruthi, *Advanc. Food Res.*, 1963, 12, 203–82; Pruthi & Lal, *Indian J. Hort.*, 1955, 12, 204; Pruthi et al., *J. sci. industr. Res.*, 1958, 17C, 129).

Utilization & Chemical Composition—The purple and yellow types of passion fruits are used for the same purposes, but the latter are somewhat inferior in flavour. Ripe fruit may be eaten fresh as dessert, but is generally not favoured for direct consumption. Its pulp or juice which is extracted either by suitable machines or on a small scale by hand scooping and screening to remove seeds, is highly acidic with a pronounced pleasant flavour. The juice is preserved by canning or freezing and is largely used in blends with less acidic fruit juices and in the preparation of squashes, cordials, syrups, carbonated beverages and jellies. It is used for flavouring candy, ice cream, cake fillings and frostings. Passion fruit juice concentrates and powder have also been prepared. Heat-processing of the fruit presents some difficulties but they are not insurmountable. The juice has been successfully spin-pasteurized [Muthuswamy, loc. cit.; Thapar, loc. cit.; Tressler & Joslyn, 729; Pruthi, *Indian Fd Packer*, 1959, 13 (7), 7; 1959, 13 (9), 7; Pruthi & Lal, *Chem.*

Age, India, 1955, **6**(2), 39; *Food Sci.*, 1959, **8**, 1; Beattie, *Perfum. essent. Oil Rec.*, 1962, **53**, 549; Pruthi, *Food Sci.*, 1963, **12**, 1.

Ripe purple fruits (av. wt., 28.4 g.) on an average yield 36.8% juice, 49.6% peel, and 13.6% residue (mostly seeds); the corresponding average yields from the yellow fruits (av. wt., 44.2 g.) are 30.9%, 61.9%, and 7.4%. Juice from the purple fruit is highly nutritious, being a good source of sugars, ascorbic acid and carotene; it contains appreciable amounts of nicotinic acid, riboflavin and mineral matter. Juice from the yellow variety contains lesser amounts of ascorbic acid and sugars, but is richer in carotene and acid content. Chemical composition of the purple and yellow passion fruits is summarized in Table 1. Sugars (sucrose, glucose and fructose) constitute the bulk of carbohydrates in both the varieties; starch consists almost entirely of amylopectin. The fruits are highly acidic, the free acid content varying from 2.4 to 4.8% in purple and up to 7.6% in yellow fruits. Citric acid forms 95% of the total acids in purple fruit, the rest being malic acid (Pruthi & Lal, *Indian J. Hort.*, 1955, **12**, 34; 1960, **17**, 133; *J. Sci. Fd Agric.*, 1959, **10**, 188; Cille & Joubert, *ibid.*, 1950 **1**, 355; Pruthi, *Advanc. Food Res.*, 1963, **12**, 203-82; *J. sci. industr. Res.*, 1958, **17B**, 238).

Juice from the ripe purple fruit contains up to 70 mg./100 g. of ascorbic acid; dehydro-ascorbic acid is present only in traces. As the fruit ripens, there is a gradual increase in the concentration of ascorbic acid and the maximum is reached at the ripe stage. Reducing substances (reductones, etc.) other than true ascorbic acid are present in large amounts in the unripe fruit, but the ripe one contains only minor quantities. The ascorbic acid content of different parts of the plant is as follows: peel of ripe fruit, 88.6; seeds, 45.4; tender stems, 67.6; green tendrils, 217.6; and green leaves, 292.5 mg./100 g. (Pruthi & Lal, *J. Sci. Fd Agric.*, 1959, **10**, 188).

The pigments present in the purple fruit juice are mostly carotenoids, among which β -carotene predominates. There are only traces of flavones. Of the total carotenoids, free xanthophylls comprise 10.3-21.5, xanthophyll esters 11.1-34.6, and epiphatic non-saponifiables (mostly carotenes) 45.7-76.3%; phytosluene, α -carotene, β -carotene, γ -carotene and three unidentified pigments have been isolated. Carotene content varies with the stage of maturity of the fruit; green fruit contains 0.595 mg., half purple fruit 0.758 mg., and purple fruit 0.917 mg./100 g. of carotene (calculated as β -carotene). As judged by the phase-partition

technique, the pigments present in the yellow passion fruit juice appear to be similar to those in the purple variety. The content of total carotenoids and xanthophyll esters is usually higher in juice from the yellow variety (Pruthi & Lal, *Food Res.*, 1958, **23**, 205; *J. Sci. Fd Agric.*, 1959, **10**, 188).

The characteristic pleasant aroma of the yellow passion fruit is found to reside in the volatile oil (d_{4}^{20} , 0.838; $[\alpha]_D^{20}$, +4.17°) which constitutes 23-43 p.p.m. of the juice. *n*-Hexyl caproate, which does not seem to have been reported earlier in any plant product, is the principal component (c. 70%) of the oil; *n*-hexyl butyrate (13.4%), ethyl caproate (11%), and ethyl butyrate (0.95%) are also present. The flavour of the purple passion fruit differs from that of the yellow variety, but the aromatic constituents of the former have not so far been isolated (Pruthi, *Advanc. Food Res.*, 1963, **12**, 203-82; Hiu & Scheuer, *J. Fd Sci.*, 1961, **26**, 557).

The nitrogen content of the passion fruit juice varies from 0.096 to 0.192%, of which non-protein nitrogen constitutes about 50%. The free amino acids reported in the purple fruit juice are leucines, valine, tyrosine, proline, threonine, glycine, aspartic acid, arginine and lysine. The presence of pectin methylesterase in the juice of the purple variety, and catalase and phenolase in the juice of the yellow variety is reported (Pruthi, *Advanc. Food Res.*, 1963, **12**, 203-82; Pruthi & Srivastava, *Sci. & Cult.*, 1963, **29**, 252; Ross & Chang, *J. agric. Fd Chem.*, 1958, **6**, 610).

The peel (or skin) of the fruit, obtained as a by-product of the juice industry, can be used for the recovery of pectin, for feeding livestock and as a manure. Feeding trials on dairy cattle showed satisfactory milk production when the dehydrated peel from yellow fruits constituted 25% of the ration. Analysis of the fresh peel gave the following values: moisture, 78.43-85.24; crude protein, 2.04-2.84; ether extr. (fat), 0.05-0.16; crude starch, 0.75-1.36; crude fibre, 4.57-7.13; phosphorus, 0.03-0.06; silica, 0.01-0.04; and potassium, 0.60-0.78%. The peel is rich in ascorbic acid (78.3-166.2 mg./100 g.), the content of which decreases with ripening of the fruit. It contains 1.64% sugars (sucrose, glucose and fructose), 0.15% organic acids (citric and malic), and 2.98% astringent matter (mostly tannic acid). The purple colour of the fresh peel is due to the presence of 1.4 mg./100 g. of an anthocyanin pigment, pelargonidin 3-diglucoside; the deterioration of the purple colour during storage is attributed to the degradation of the pigment (Pruthi, *Food Sci.*, 1960, **9**, 397;

Otagaki & Matsumoto, *J. agric. Fd Chem.*, 1958, **6**, 54; Susheela et al., *Indian J. appl. Chem.*, 1960, **23**, 169; Pruthi et al., *Def. Sci. J.*, 1960, **10**, 93; Pruthi et al., *J. Fd Sci.*, 1961, **26**, 385).

The peel of purple fruits is fairly rich in pectin [1.5–2.5% on fresh wt. basis] and 9–15% (as calcium pectate) on dry wt. basis. Pectinesterase is also present in the peel and has to be inactivated by steam blanching for 5 minutes, before maximum yield of pectin can be obtained. The pectin (methoxyl content 9–10%, anhydrouronic acid 85–91%, and jelly grade 175–200) is of good quality, with jellying properties comparable to those of citrus pectin. It is reported to hydrolyze enzymically to D-galacturonic acid, L-arabinose and galactose. According to one source, unlike other pectins, it contains no galactose but instead sorbose. For jelly manufacture, the pectin from the peel of yellow variety (yield, c. 20% on dry wt. basis) is somewhat inferior to that from purple

variety (Pruthi, *Food Sci.*, 1960, **9**, 397; *Chem. Abstr.*, 1957, **51**, 9973; Martin & Reuter, *Nature, Lond.*, 1949, **164**, 407; Pruthi, *Advanc. Food Res.*, 1963, **12**, 203–82).

The seeds constitute 7–22% (av. 13.6%) of the purple and 2.4–12.4% (av. 7.4%) of the yellow fruits. An analysis of the air-dried seeds of the purple variety from India gave the following values: moisture, 5.4; ether extr., 23.8; crude fibre, 53.7; protein, 11.1; N-free extr., 5.1; total ash, 1.84; and ash insol. in HCl, 0.35%; calcium, 80; iron, 18; and phosphorus, 640 mg./100 g. The seeds on cold-pressing yielded up to 19% of a pale yellow semi-drying oil, with a mild pleasant taste and having the following characteristics: sp. gr.^{25/40}, 0.9214; *n*²⁵, 1.4727; acid val., 0.20; iod. val., 142.1; thiocyanogen val., 80.9; sap. val., 190.3; unsapon. matter, 0.65%; saturated fatty acids, 8.90%; and unsaturated fatty acids, 84.09%. The fatty acid composition of a

TABLE I—CHEMICAL COMPOSITION OF FRUITS OF PASSIFLORA spp.

	<i>P. edulis</i>		<i>P. quadrangularis</i> var. <i>macrocarpa</i>	<i>P. mollissima</i> Banana passion fruit juice*		
	Passion fruit juice					
	Purple variety†	Yellow variety				
	A*	B‡				
Moisture, %	80.4	81.5	89.0	91.8		
Ether extr., %	0.05	..	0.2	0.1		
Fibre, %	0.05	..	1.2	0.6		
Soluble solids, %	17.3	14.5	..	..
Acidity, %	3.4	6.0	..	..
Reducing sugars, %	4.6	1.6	..	..
Total sugars, %	10.00	6.70	7.70†	6.6†		
Protein, %	0.80	..	1.20	0.40		
Mineral matter, %	0.46	..	0.70	0.40		
Calcium, mg./100 g.	12.14	..	10.00	10.00		
Phosphorus, mg./100 g.	30.10	..	30.00	10.00		
Iron, mg./100 g.	3.12	..	0.70	0.40		
Ascorbic acid, mg./100 g.	34.6	12.6	13.0	64.0		
Thiamine, mg./100 g.	0.03	..	0.01	0.103		
Riboflavin, mg./100 g.	0.168	..	0.023	0.023		
Nicotinic acid, mg./100 g.	1.71	..	..	2.4
Carotene (as Vitamin A), I.U./100 g.	1,345	..	3,284	6		

* Pruthi, *Advanc. Food Res.*, 1963, **12**, 203–82.† Belavady & Balasubramanian, *Indian J. agric. Sci.*, 1959, **29** (2 & 3), 151.

‡ Also contains: calcium pectate, 0.05%; starch, 2.4%; and tannins, 4.2 mg./100 g.

§ Values refer to total carbohydrates.

PASSIFLORA

sample of oil (iod. val., 140.4) from California was as follows: palmitic, 6.78 ; stearic, 1.76 ; arachidic, 0.34 ; oleic, 19.0 ; linoleic, 59.9 ; and linolenic, 5.4%. The oil from seeds of yellow fruits is similar to that from purple variety. The oil, if produced in quantity, could be used for edible purposes ; at 5% level of intake, digestibility coefficient of the oil is 98%. It is suitable for use in the paint and varnish industry, particularly in the manufacture of non-yellowing stoving alkyds. The residual seed cake or meal has a high fibre content (50–55%) and is unsuitable as an animal feed or as manure (Pruthi, *Indian Oil & Soap J.*, 1962–63, **28**, 55 ; Pruthi & Lal, *Indian J. Hort.*, 1955, **12**, 34 ; Otagaki & Matsumoto, loc. cit. ; Jamieson, 297 ; Jordan *et al.*, 79 ; Pruthi, *Advanc. Food Res.*, 1963, **12**, 203–82).

The leaves are used in medicine along with those of *P. incarnata* (q.v.). They are reported to contain a bitter principle maracugine, resin and resin acids and tannin, and are exceptionally rich in ascorbic acid. Stems and roots are slightly cyanogenic (Hoppe, 644 ; Schindler, 146 ; *Chem. Abstr.*, 1941, **35**, 1832 ; Burkhill, II, 1676).

P. foetida Linn. STINKING PASSION FLOWER

Chakravarty, *Bull. bot. Soc. Beng.*, 1949, **3**, 57 ; Bor & Raizada, 258, Fig. 151.

TEL.—*Tellajumiki* ; TAM.—*Mupparisavalli*, *sirup-punaikkalli* ; KAN.—*Kukkiballi* ; MAL.—*Chadayan*, *poochapazham*.

A herbaceous climber emitting a foetid smell when bruised, native of tropical America, escaped from cultivation and found wild in several parts of India. Leaves alternate, 3-lobed ; flowers with an epicalyx of pinnatifid bracteoles, cut up into moss-like, gland tipped, pectinate segments ; fruit globose, up to 2.5 cm. in diam., hairy.

This species is extremely polymorphic and includes as many as 38 varieties. The plant is more or less viscid and densely hirsute and of little ornamental value. When bruised, it emits a foetid smell which prevents animals from eating it. The plant can be of some value as a cover crop or green manure (Brizicky, *J. Arnold Arbor*, 1961, **42**, 204 : Burkhill, II, 1676 : Dalziel, 51).

The fruit is edible when ripe, but unripe fruit is poisonous and contains a cyanogenic glucoside. The edible portion (60%) of the ripe fruit contains : ash, 1.2% ; calcium, 10 ; phosphorus, 6 ; iron, 0.8 ; riboflavin, 0.08 ; and niacin, 0.4 mg./100 g. ; thiamine, traces. The fruit peel, seeds, and leaves contain an

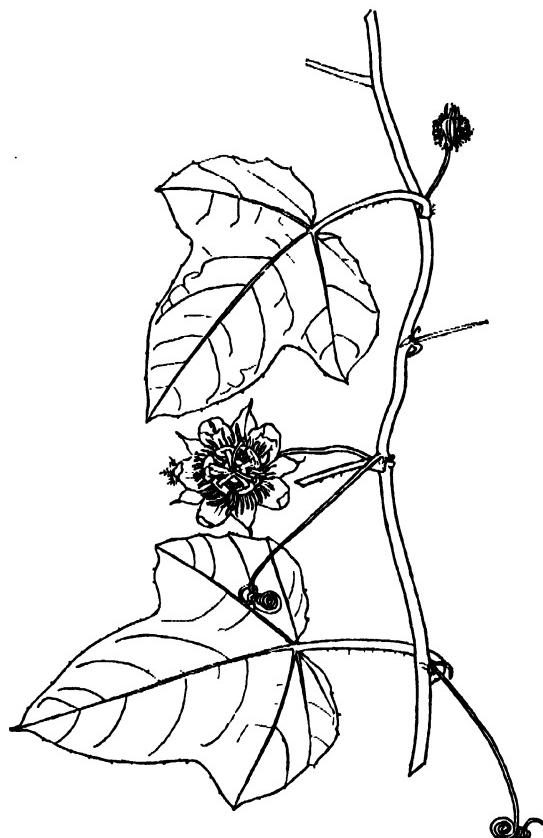


FIG. 121—PASSIFLORA FOETIDA—FLOWERING BRANCH

unstable compound which yields hydrocyanic acid and acetone. The fruits are said to be emetic and a decoction of them is used for asthma and biliousness. The leaves are used as a dressing for wounds, and a decoction of them and roots is said to be an emmenagogue and useful in hysteria. The plant is said to be used for curing itches (Dalziel, 51 ; *Handb. Inst. Nutr. Philipp.*, No. 1, 1957, 34 ; Wehmer, II, 805 ; Chopra *et al.*, 469 ; Kirt. & Basu, II, 1103 ; Burkhill, II, 1676).

P. incarnata Linn. MAYPOP

Chakravarty, *Bull. bot. Soc. Beng.*, 1949, **3**, 61 ; Bor & Raizada, 252, Pl. 92.

A wide spreading climber, native of South-East United States of America, grown frequently in gardens as an ornamental. Stems wiry : leaves 3-lobed, serrate ; flowers 5–7 cm. across, pale pink in colour ; fruits ovoid or globose, 3–5 cm. long.

This is a fine climber suitable for covering arbours,

verandahs and arches. It can be propagated by seed or layering. The fruit is edible when ripe (Bailey, 1947, II, 2484).

The flowering and fruiting portions are dried and preserved and used as a drug in preparation of certain proprietary products (Passi-Barb., Barbi-flora, Bromo-Flora and Passiphen). They are considered anti-spasmodic, sedative and narcotic and useful in neuralgia, insomnia and epilepsy : it is also serviceable in de-acustoming the morphine addicts. The root extract is also used in treatment of ulcers, haemorrhoids, etc. (U.S.D., 1955, 1797 : Claus, 1961, 375 : Steinmetz, 1957, 801 : Hocking, 163 : Schindler, 147).

The drug contains several alkaloids including harman (methylcarboline, $C_{12}H_{10}N_2$, m.p. 233°), harmine ($C_{13}H_{12}ON_2$, m.p. 266°) and harmol ($C_{12}H_{10}ON_2$, m.p. 306°) ; it contains also a water-soluble substance (isolated as a mercury salt, $C_{10}H_{22}O_8N.HgCl_2$) which lowers blood pressure and effects contraction of smooth muscles of the gut and uterus. The sedative action of the drug is attributed to the presence of a water-soluble weak base, not yet identified, but possibly identical with maracugine (Chem. Abstr., 1960, 54, 16751-52 : 1949, 43, 6788 : Heilbron & Bunbury, II, 631 : Schindler, 147 : Ruggy & Smith, J. Amer. pharm. Ass., sci. Edn, 1940, 29, 207, 245).

P. laurifolia Linn. JAMAICA HONEY SUCKLE, WATER LEMON

Chakravarty, Bull. bot. Soc. Beng., 1949, 3, 53.

A rampant climber, native of tropical America, sometimes grown as an ornamental. Leaves large, glossy : flowers large, sweet-scented, violet-purple : fruits ellipsoidal or ovate, 5-8 cm. long, orange yellow, with an edible pulp.

This plant has been cultivated in some areas and is said to have become naturalized in parts of Assam. It has been tried as a cover crop, but the foliage produces hydrocyanic acid and hence is poisonous (Gopalaswamiengar, 360 : Burkill, II, 1677).

The fruits are edible (pantothenic acid content in pulp, 1.55 and in peel, 1.87 mg./100 g.). Fruit peel, seed and leaves contain hydrocyanic acid : leaves contain 387 mg./100 g. of vitamin C. The leaves are said to be used as anthelmintic and seeds as cardio-tonic, hypnotic, emollient and diaphoretic (Asenjo & Muniz, Food Res., 1955, 20, 47 : Wehmer, II, 805 : Chem. Abstr., 1941, 35, 1832 : Hocking, 162).

P. mollissima Bailey syn. *Tacsonia mollissima* H.B. & K. BANANA PASSION FRUIT

Chakravarty, Bull. bot. Soc. Beng., 1949, 3, 55 : Bailey, 1947, III, 2486.

A feeble climber, with stem densely and softly tomentose, introduced into India and grown in parts of Madras State. Leaves deeply trilobed, serrate-dentate : flowers large, pinkish, with a long tubular calyx : fruits oblong-ovoid, 6-7 cm. in diam., softly tomentose.

This plant is valued for its ornamental flowers. It is said to thrive well and fruit abundantly in Nilgiris (Ootacamund). On an average 40-50 fruits are borne by a vine from the sixth year of planting. The fruits are edible, with a fleshy pulp of a rather agreeable flavour. The chemical composition and properties of the juice are given in Table 1 (Firninger, 199, 515).

P. quadrangularis Linn. TRUE OR GIANT GRANADILLA

Chakravarty, Bull. bot. Soc. Beng., 1949, 3, 64 : Bor & Raizada, 245, Fig. 142.

A robust climber with quadrangular winged stem, native of tropical America, sometimes grown in Indian gardens for its edible fruits and showy flowers. It is reported to have become naturalized as a garden escape. Leaves ovate ; flowers large, 10.0 cm. across, of a pinkish white colour : fruit yellow or yellish green in colour, 15-25 cm. long with a thin brittle pericarp enclosing an edible pulp.

This species is widely grown in the tropics and is very variable, both as a vine and for its edible fruits. A variety (*P. quadrangularis* var. *macrocarpa* Mast.) with a large fruit reaching 30 cm. in length is said to have a better flavoured flesh. Giant granadilla is essentially a tropical plant which requires high temperatures, accompanied by high humidity for fruiting. It thrives well up to an elevation of 750 m. Under dry atmospheric conditions the flowers produce little or no pollen and the fruit set is poor. For successful culture, it requires a fertile soil with good moisture holding capacity and free drainage [Bailey, 1947, II, 2483 : Wills & Stephens, Qd agric. J., 1954, 79, 205 : Saha-devan & Vijayan, Indian Hort., 1956-57, 1(3), 25].

Propagation can be effected by seeds or cuttings. Cuttings 35-60 cm. long taken from vigorous lateral branches may be used for planting. The vines have to be supported on horizontal trellis which must be solidly constructed as it has to support a considerable weight (Wills & Stephens, loc. cit.).

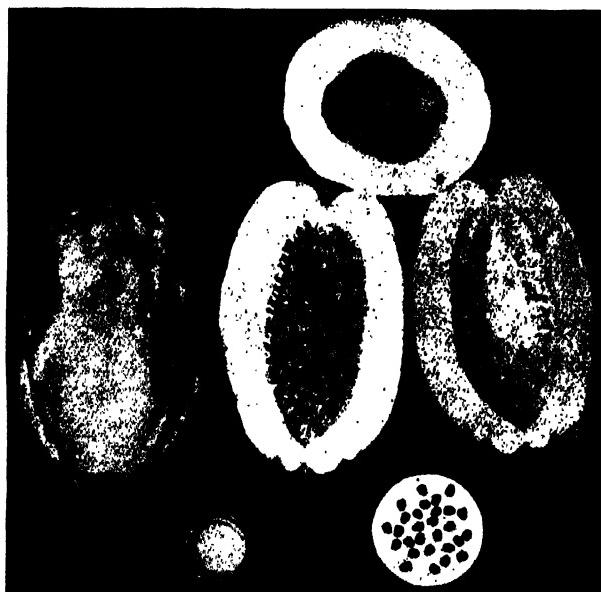


Photo : J. S. Pruthi, Nagpur

FIG. 122—PASSIFLORA QUADRANGULARIS—FRUIT AND SEEDS

Giant granadilla is said to be normally less seasonal than the purple passion fruit, the plant being in fruit in all seasons of the year. The smaller-fruited granadilla sets freely by natural pollination but the large-fruited variety is said to require hand pollination to set a good crop, the best result being obtained by self pollinating the flowers within 4–6 hours after the buds open. The yield of a granadilla plant in full crop is said to be about 70–120 fruits per year while the large-fruited variety yields 25–35 fruits per year.

The fruit pulp is slightly acid, with a pleasant flavour. In the green state the fruit is said to make an excellent vegetable and when ripe it is eaten as dessert. Chemical composition of the edible flesh which constitutes up to 87% of fresh fruits is summarized in Table 1 [Sahadevan & Vijayan, loc. cit. ; Belavady & Balasubramanian, *Indian J. agric. Sci.*, 1959, 29(2 & 3), 151].

The tuberous roots are reported sometimes to be cooked and eaten like yam (Krumbiegel, 56 ; Williams & Williams, 247).

The fruit is accredited with narcotic properties when eaten in excess. The peel and seeds of green fruits, leaves and roots are cyanogenic. Roots are reported to be poisonous. They contain an alkaloid passiflorin which is identical with harman from *P. incarnata* (q.v.) (Wehmer, II, 805 ; Schindler, 147 : *Chem. Abstr.*, 1956, 50, 14183 ; Hoppe, 644 : Chopra et al., 469).

Some of the other species of the genus reported to have been introduced into India and grown as ornamentals are: *P. biflora* Lam. syn. *P. lanata* Sm. ; *P. caerulea* Linn. ; *P. calcarata* Mast. ; *P. ciliata* Dryand (syn. *P. foetida* var. *ciliata*) ; *P. gracilis* Jacq. ex Link ; *P. holoserica* Linn. ; *P. kermesiana* Link & Otto ; *P. leschenaultii* DC. ; *P. morifolia* Mast. ; *P. racemosa* Brot. ; *P. suberosa* Linn. (syn. *P. minimia* Linn.) ; *P. subpetiata* Ort. ; *P. stipulata* Aubl. ; and *P. trifaciata* Lem. (Chakravarty, *Bull. bot. Soc. Beng.*, 1949, 3, 45–71).

P. caerulea Linn., a native of Brazil, is a slender but vigorous climber with 3–5 lobed leaves and large purplish blue flowers, borne plentifully almost throughout the year. The plant is said to contain a cyanogenetic glycoside. *P. racemosa* Brot., also a native of Brazil, is a very choice and handsome climber with large scarlet or deep red flowers, borne in great profusion (Chakravarty, *Bull. bot. Soc. Beng.*, 1949, 3, 45–71 ; Firminger, 512 15 ; Bor & Raizada, 240–64 ; Hocking, 162).

Passion Fruit — see *Passiflora*

PASTINACA Linn. (*Umbelliferae*)

A genus of herbs distributed chiefly in the north temperate zone of the Old World. One species, *P. sativa*, is widely cultivated in Europe, America and other countries for its fleshy edible roots. In India, it is occasionally grown as an annual in kitchen gardens.

P. sativa Linn. syn. *Peucedanum sativum* Benth. & Hook. f. PARSNIP

Fl. Malesiana, Ser. I, 4(2), 138 ; Butcher, I, 878.

An aromatic, biennial herb with a grooved, erect stem, 0.3–1.7 m. in height, arising from a white, fleshy tap-root, 25–30 cm. or more in length. Leaves pinnate: leaflets 2–5 pairs, often 3-lobate to 3-partite, irregularly crenate; flowers in terminal compound umbels, yellow; fruit (commonly called seed) broad-elliptic and ridged, consisting of two mericarps.

Parsnip is not an important crop in India, and is grown only for table use. Important amongst the horticultural varieties are Hollow Crown, Student and Large Guernsey. The cultivation of parsnips, in general, is similar to that of carrots. The plants thrive in a cool climate, and in India, hills are best suited, where sowing is done in March–May. In the plains parsnips are sown in October–November. Fresh fruits are used for sowing as they lose their viability

in a year or so. In a kitchen garden, a row 10–15 m. long, planted with about 8–15 g. of seed, produces enough parsnips for home consumption. Spraying with herbicidal oil in the pre-emergence period is helpful in checking the weeds. Parsnips may also be grown in mixture with radish and fenugreek which indicate the lines and also yield an earlier crop (Firminger, 150 : Purewal, 37 : Gopalaswamiengar, 543 : Knott, 249 : Beattie & Beattie, *Leafl. U.S. Dep. Agric.*, No. 154, 1938 ; Choudhri, 135).

Germination is slow, and the seedlings establish themselves in 5–6 weeks : at this stage they are thinned out 7–10 cm. apart. The roots attain maturity in 3–5 months and penetrate the ground to a considerable depth, necessitating careful digging at the time of harvesting. As fully mature roots develop a lot of woody fibre, young roots are preferred for table use. Parsnips are frost resistant and can be left unearthened at site near about the freezing temperature for a few months : during this period the sucrose content increases and the parsnips are said to develop a better flavour (Thompson & Kelly, 335–36 : Purewal, 38 : Firminger, 150 : Knott, 250 : Winton & Winton, II, 89).

Parsnips are eaten as a vegetable and salad, and sometimes employed in the preparation of soups and wines. They are also fed to livestock, but their use as fodder may need caution as parsnip-poisoning amongst horses has been reported. Analysis of parsnips shows the following values: moisture, 72.4 ; protein, 1.3 ; fat, 0.3 ; carbohydrates, 23.2 ; fibre, 1.7 ; and mineral matter, 1.1% : calcium, 50 mg. ; phosphorus, 40 mg. ; iron, 0.4 mg. ; carotene (as vitamin A), 30 I.U. ; thiamine, 0.31 mg. ; niacin, 0.4 mg. ; and ascorbic acid, 16 mg./100 g. Riboflavin (0.06–0.12 mg./100 g.) has also been reported. Experiments conducted on rats indicated that the calcium of parsnips was 88% available as that of milk. Parsnips are reported to be a good source of pyruvic carboxylase and a heat labile factor acting directly on oxalacetate (Uphof, 268 : Hill, 361 : Connor, *Bull. Dep. sci. industr. Res. N.Z.*, No. 99, 1951, 76 ; *IIIth Bull.*, No. 23, 1951, 36 : Jacobs, II, 1296 ; Sherman, 691).

The herb is said to possess diuretic and carminative properties. The fruit is used as a folk medicine for stomach, bladder and stone troubles. Almost all aerial parts of the plant on local application produce dermatological reactions or percutaneous photosensitization in susceptible persons. The phytophotodermic activity of the fruit is attributed to the presence of three crystalline furocoumarins, viz.

TABLE I—CHARACTERISTICS OF ESSENTIAL OILS OF *P. SATIVA*¹

	Dried umbels 0.3	Dried seeds 1.47	Dried root 0.35
Yield, %	0.3	1.47	0.35
Colour	Dark brown	Bright yellow	Bright yellow
Odour	Resembling ambrette seed oil	..	Reminiscent of vetiver oil
d ¹⁵	1.0168	0.8736	1.0765
μ_{D}^{20}	1.5005	1.4301	1.5250
[α]D	0.83	-0.15*	-0.17
Acid val.	4.2	4.4	3.9
Ester val.	62.9	240.6	12.6
Ester val. after acetylation	86.2	276.0	33.7
Solubility	6.5 vol. of 80% alcohol with separation of paraffin	2.5 vol. or more of 80% alcohol	0.6 vol. or more of 90% alcohol

* Parry, I, 327.

xanthotoxin (0.1%), imperatorin (0.17%) and bergapten (0.38%) : the leaves contain only xanthotoxin (0.08%) which is the most potent of these coumarins. These coumarins have been isolated earlier from the fruits of *Ammi majus* Linn., a plant used in Egypt for leucoderma. Recently another coumarin pastinacin ($C_{12}H_{10}O_4$, m.p. 124–38°), showing spasmolytic action, has been isolated from the fruit (Burkhill, II, 1677 : Hoppe, 645 : Fahmy *et al.*, *J. Pharm., Lond.*, 1956, 8, 653 ; Soine *et al.*, *J. Amer. pharm. Ass., sci. Edn.*, 1956, 45, 426 ; *Chem. Abstr.*, 1959, 53, 10566 ; 1960, 54, 19664).

Volatile oils, present in different parts of the plant, consist chiefly of octyl butyrate and octyl propionate. The characteristics of oils from the different parts of the plant are summarized in Table I (Parry, I, 327).

Dried mericarps on extraction with carbon tetrachloride yield 17.3% of a fatty oil with the following characteristics: sap. val., 206.2 ; iod. val., 92.7 ; acidity (as oleic acid), 12.9 ; and unsapon. matter, 2.6%. The fatty acid composition of the oil is as follows: palmitic, 1 ; petroselinic, 46 ; oleic, 32 ; and linoleic, 21% (Christian & Hilditch, *Biochem. J.*, 1929, 23, 327).

Patchouli — see *Pogostemon*

PAULOWNIA Sieb. & Zucc. (*Scrophulariaceae*)

Parker, 374.

A genus of ornamental trees native of East Asia.

PAULOWNIA

and introduced in several other parts of the world. One species is grown in Indian gardens.

P. tomentosa Steud. syn. *P. imperialis* Sieb. & Zucc. is an elegant, rapid growing tree, up to 15 m. in height, with large, handsome, cordate leaves and beautiful panicles of fragrant, violet or white flowers appearing before the leaves. In India, it is suited only to the cooler parts, flowering on the hills during the rainy season. Propagation is done by seed or by root cuttings (Firmering, 427).

The wood is reddish brown and very light (wt., 320 kg./cu. m.), showing almost no shrinkage. It is excellent for beams and poles but the timber is scarce and expensive. It is, therefore, used mostly for fine wood work, such as musical instruments, book-cases, sandals, furniture, linings and drawers of small cabinets, and veneering. Paulownia wood is recommended for the manufacture of crating and boxing lumber for airplane express or freight shipment. The wood is also used in small boat building and for carving. The charcoal made from this wood is used in high class fireworks and in the preparation of gun powder (Howard, 284; Uphof, 268; Hu, *Econ. Bot.*, 1961, **15**, 11).

The wood and bark are reported to have astringent properties. The bark contains syringen ($C_{17}H_{21}O_9H_2O$, m.p. 190–91° : yield, 0.3%). The leaves and flowers contain a toxic crystalline glucoside which causes the death of animals with excitation of the voluntary and reflex movements and progressive paralysis : the glucoside has a diastolic effect on isolated heart. The fruit contains a crystalline yellow colouring matter. The seeds yield 22% of a drying oil known as Toi or Abur oil (iod. val., 149–158) used in preparation of papers (Roi, 416; *Chem. Abstr.*, 1938, **32**, 3485; 1960, **54**, 3609; Wehmer, II, 1133; Hoppe, 646; Mensier, 432).

PAVETTA Linn. (*Rubiaceae*)

A genus of shrubs and small trees, allied to *Ixora*, distributed mostly in the tropical and sub-tropical regions of the Old World. About 30 species have been recorded in India in a wild state and a few exotics are grown in Indian gardens.

**P. indica* Linn. WHITE PAVETTA

D.E.P., VI (1), 114; Fl. Br. Ind., III, 150; Kirt. & Basu, Pl. 505.

* According to some authors this species is confined only to S. India. Plants from other regions are referred by them to *P. crassicaulis* Bremek. [Santapau & Merchant, *Bull. bot. Surv. India*, 1961, **3**(2), 107].

SANS.—*Papata*; HINDI—*Kankra, kathachampa, papari*; BENG.—*Jui, kukura-chura*; MAR.—*Papadi*; GUJ.—*Papat*; TEL.—*Duyi papata, kondu papata, lakka papidi*; TAM.—*Pavattai*; KAN.—*Pavati, pappadi*; MAL.—*Pavatta*; ORIYA—*Kotapengu, kukuchalia, phingi*.

DEHRA DUN—*Angari*; KUMAUN—*Padera, puldu*; NEPAL—*Takali, kangyaphul*; LEPCHA—*Sundok*; SANTAL *Budhi ghasit*; ASSAM—*Gobor-hitha, sam-suku*.

A very variable shrub or a small tree distributed throughout the greater part of India ascending to an altitude of c. 1,500 m. in the Himalayas : it has also been recorded from the Andamans. Leaves very variable, elliptic-oblong to elliptic-lanceolate and obovate-oblong, glossy-green ; flowers white, fragrant in terminal corymbose cymes ; fruit globose, black, succulent, pea-sized.

The ripe fruit has a sweetish taste and is eaten raw or pickled. The flowers are consumed fresh as food in some parts of Maharashtra, and their fragrant infusion is used in Thailand as a cosmetic (Burkill, II, 1678).

The roots are said to possess purgative, aperient, diuretic and tonic properties, and are prescribed in visceral obstructions, jaundice, headache, urinary diseases and dropsical affections. Commercially available roots are crooked in shape, varying from 6 to 25 mm. in diam., and have a sweetish-bitter, aromatic taste. The leaves and roots are employed in the preparation of poultices for boils and itches : a decoction of the leaves is used as a lotion for ulcerated nose and for haemorrhoids (Burkill, II, 1678; Quisumbing, 925; Bressers, 76; Datta & Mukerji, *Bull. Pharmacogn. Lab.*, No. 1, 1950, 59).

The root bark appears to be the most active part. It contains d-mannitol ; presence of a bitter glucoside (m.p. 120°) related to salicin, as recorded by earlier workers, has not been confirmed. On boiling with water, the roots give off a pleasant odour. The stem is reported to contain an essential oil (0.55%), a resin (1.9%), an alkaloid (1.4%) and pectic substance (7.8%). The leaves give a positive test for alkaloids (Banerjee & Ghosh, *Sci. & Cult.*, 1956–57, **22**, 114; Datta & Mukerji, loc. cit.; Quisumbing, 925; Webb, *Bull. sci. industr. Res. Org. Aust.*, No. 268, 1952, 74).

The wood (wt., 753–945 kg./cu. m.) is used as fuel. An infusion of it is given in rheumatism (Gamble, 422; Cameron, 165; Kirt. & Basu, II, 1292).

P. subcapitata Hook. f., a small shrub very closely allied to *P. indica* but having flowers in terminal,

sessile compact cymes, is found in Khasi and Jaintia hills and in Nowgong and Sibsagar districts of Assam. The leaves are reported to be eaten (Fl. Assam, III, 73).

P. tomentosa Roxb. ex Sm. syn. *P. indica* var. *tomentosa* Hook. f. (Fl. Br. Ind.) in part is a bush or a tree found in most parts of India. It is closely allied to *P. indica* and is similarly used.

Some of the *Pavetta* spp. have nitrogen-fixing bacteria in the flecks or warts found on the leaves and are said to yield a rich green manure; they are also useful as a cover-crop in shady situations (Corner, I, 552).

PAVONIA Cav. (*Malvaceae*)

A genus of herbs and shrubs distributed in the warmer parts of the world, chiefly in America. Nine species are found wild in India and one species has been introduced into gardens.

P. odorata Willd.

D.E.P., VI (1), 115; Fl. Br. Ind., I, 331; Kirt. & Basu, Pl. 128.

HINDI & BENG.—*Sugandha-bala*; MAR.—*Kalavala*; GUJ.—*Kalowalo*; TEL.—*Erra kuti, chitti benda, tige benda*; TAM.—*Peramutti, avibattam*; KAN.—*Balarakkasi, peramutiberu*; MAL.—*Kuruntotti*.

BHAR.—*Kotle ara, naguri ara*.

A pubescent herb found in open woods and waste places in the Deccan Peninsula, parts of Bengal, Bihar, Orissa, Uttar Pradesh and Rajasthan. Leaves cordate-ovate, shallowly 3–5 lobed, dentate or the lower ones entire; flowers axillary, pink or white, fragrant.

The herb is cultivated in gardens for its fragrant flowers, and sometimes for its edible leaves. The herb and the roots possess a musk-like odour. The roots are reported to be used in Indian perfumery, and enter into the composition of a perfume known as 'Hina'. The roots are aromatic, and possess refrigerant, antipyretic, stomachic and astringent properties. They are used in dysentery and inflammation and haemorrhage of intestines (Bressers, 11; Shukla & Nigam, *J. Instn Chem. India*, 1961, 33, 229; Kirt. & Basu, I, 324; Hocking, 163).

Steam-distillation of dried roots yield (0.5%) a green coloured essential oil, with an offensive odour. It has the following characteristics: d^{30} , 0.9345; $[n]_D^{30}$, -15.13° ; n_D^{30} , 1.4612; acid val., 310; and ester val., 31. The oil contains: isovaleric acid, 69; isovaleraldehyde, 3; aromadendrene, 8; a tricyclic sesquiterpene pavonene ($C_{15}H_{24}$, b.p. $124-25^\circ/10$ mm.).

6; α -terpinene, 5; and azulene, 4%; a sesquiterpene alcohol, named pavonanol ($C_{15}H_{24}O$, m.p. $52-55^\circ$) has been isolated. Removal of isovaleric acid, by treatment with saturated sodium carbonate solution and subsequent extraction with ether, gives an oil which possesses a pleasant aroma (Baslas, *Perfum. essent. Oil Rec.*, 1959, 50, 896).

P. zeylanica Cav. (TEL.—*Pera mutti, chinna mudda pulagam*; TAM.—*Sitha mutti*; KAN.—*Antutoogari, chittaamuttigida*) is a herb resembling *P. odorata* and having the same distribution. It is used as febrifuge and anthelmintic (Caius, *J. Bombay nat. Hist. Soc.*, 1942-43, 43, 497).

Both *P. odorata* and *P. zeylanica* yield a tough fibre resembling that obtained from *Hibiscus* spp., but the fibre from *Pavonia* spp. is comparatively whiter, softer and of a finer texture. Chemical analysis of the fibre indicates that it is of a good quality (cellulose, 74.7%), but the short length of the ultimate fibre (1–1.5 mm.) is a drawback for its commercial exploitation.

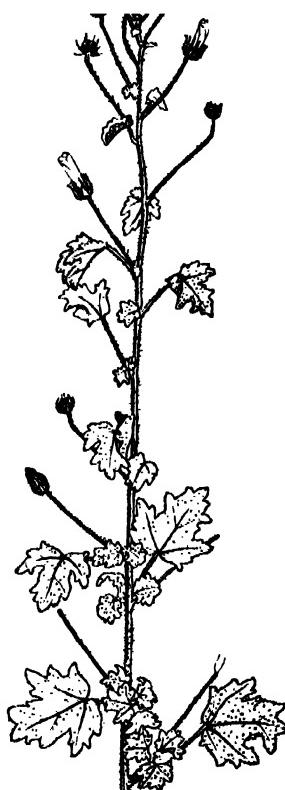


FIG. 123—PAVONIA ZEYLANICA—FLOWERING BRANCH

PAYENA

PAYENA A. DC. (*Sapotaceae*)

D.E.P., VI(1), 116; C.P., 628; Fl. Br. Ind., III, 547.

A genus of tree distributed from the Andaman Islands to Burma, Indonesia and Philippines.

P. lucida A. DC. is a medium-sized to tall tree with elliptic-lanceolate to ovate leaves, clusters of whitish flowers and ovoid fruits, found in the Andaman and Nicobar Islands. The wood is reported to be durable and used for house posts and planking. The tree yields an inferior type of gutta percha, sometimes used as an adulterant of the genuine product. Seeds contain basic acid (van Bruggen, *Blumea*, 1958-59, 9, 111; Burkill, II, 1681; Heywood & Kon, *J. chem. Soc.*, 1940, 713).

Pea, Australian — see *Dolichos*

Pea, Chick — see *Cicer*

Pea, Common, Field or Garden — see *Pisum*

Pea, Congo or Pigeon — see *Cajanus*

Pea, Cow — see *Vigna*

Pea, Grass, Sweet or Tangier — see *Lathyrus*

Peaberry — see *Coffea*

Peach — see *Prunus*

Peacock Flower — see *Caesalpinia*

Peafowls — see *Birds*

Peanut — see *Arachis*

Pear, Common — see *Pyrus*

Pear, Prickly — see *Opuntia*

Pearl Millet — see *Pennisetum*

Pearls — see *Oysters*

Pecan Nut — see *Carya*

Pectolite — see *Jade*

PEDALIUM Linn. (*Pedaliaceae*)

A small genus of herbs distributed in tropical Africa, Ceylon, India and Mexico. One species occurs in India.

P. murex Linn.

D.E.P., VI(1), 123; Fl. Br. Ind., IV, 386; Kirt. & Basu, Pl. 711.

HINDI.—*Bara-gokhru, kadvagokhru*; **BENG.**.—*Baraghokru*; **MAR.**.—*Hatticharatta, mothe-gokharu*; **Guj.**.—*Motto-gokharu, kadvaghokru*; **TEL.**.—*Enugu-*

palleru, pedda palleru; **TAM.**.—*Anai-nerinji, perunerinji*; **KAN.**.—*Annegalu-gida*; **MAL.**.—*Kaka-mulla, ana nerinnil*; **ORIYA**.—*Gokara, gokshura*.

PUNJAB.—*Gokru kalan*.

A diffuse, more or less succulent herb with rather foetid-smelling, slime-secreting glands, occurring as a weed of waste places in the Deccan Peninsula, particularly near the coast; it occurs also in Delhi, Rajasthan and Punjab. Leaves ovate or ovate-oblong; flowers bright yellow, solitary, axillary; fruit bluntly angled, spinous; seeds oblong, black.

A viscid mucilage, resembling that of gum arabic, separates out by simple agitation of young twigs, leaves, fruits or seeds in water or milk; the mucilage does not materially affect the taste, colour and smell of the liquid. The mucilaginous infusion so formed is credited with demulcent, diuretic and tonic properties, and used in the diseases of the urino-genital system, such as gonorrhoea, dysuria, etc.; it is said to dissolve calculi. A decoction of the leaves given to cases of gonorrhoea, however, did not give satisfactory results. The leaves are applied to ulcers, and a decoction of the roots is said to be antibilious. In Africa, the leaves are consumed as a vegetable (Kirt. & Basu, III, 1857; Kanny Lall Dey, 231; Komar, 1919, 18; Nadkarni, I, 927; Uphof, 269).

The fruits are reported to be sold in bazaars for medicinal uses. They contain an alkaloid, a greenish fatty oil, small amount of resin, and ash (5.4%) (Fl. Delhi, 262; Dymock, Warden & Hopper, III, 36).

PEDICULARIS Linn. (*Scrophulariaceae*)

D.E.P., V(1), 124; Fl. Br. Ind., IV, 306; Coventry, II, Pl. 46 & 47.

A genus of semi-parasitic herbs, popularly known as Louseworts, distributed chiefly in the temperate and alpine regions of the northern hemisphere, with a few species in the mountains of South America. Nearly a hundred species have been reported from India.

P. pectinata Wall. (**PUNJAB**.—*Mishran, michren*) and *P. siphonantha* D. Don are perennial herbs distributed in the Himalayas from Kashmir eastwards, the former occurring at altitudes of 2,000-4,300 m., extending to Kumaun, and the latter occurring at 2,400-5,000 m. and extending to Sikkim.

Both the herbs are considered medicinal and used as diuretics. The leaves of *P. pectinata* are said to possess astringent and haemostatic properties, and are given to stop spitting of blood (Kirt. & Basu, III, 1832; Nadkarni, I, 927).

PEDILANTHUS Poit. (*Euphorbiaceae*)

A genus of succulent shrubs, native of tropical America, with several species grown for ornament in warm countries. One species, *P. tithymaloides*, is often grown in Indian gardens and has become naturalized in certain parts.

P. tithymaloides Poit. SLIPPER-PLANT

Fl. Br. Ind., V, 239; Bailey, 1949, 619.

BENG.—*Belati-sij*.

BOMBAY—*Vilayti-sher*; MADHYA PRADESH—*Nagphani, nagdaman*; MUNDARI—*Airi*.

An ornamental laticiferous shrub grown in hedges and as a pot-plant; occasionally met with as an escape. Leaves ovate or ovate-lanceolate, succulent; cyathia in terminal crowded cymes; involucle scarlet, bright red or orange, slipper-shaped.

Slipper-plant is hardy and can be easily raised from cuttings. It is not eaten by cattle owing to the acrid latex and consequently grown as hedges [Desai, *Indian Hort.*, 1958–59, 3(4), 14; Gopalaswamiengar, 182–83].

The root is a powerful emetic, and is used in West Indies under the name of Ipecacuanha. The latex has emetic, irritant and caustic properties, and is said to be used in venereal troubles. It is also applied to warts and leucoderma patches (Berkill, II, 1683; Quisumbing, 525).

The latex is reported to contain (total solids, 0.4%) euphorbin, cerin, myricin, resin and a fatty oil; the resin forms nearly half of the dry matter (Wehmer, II, 689; Viswa Nath, *J. sci. industr. Res.*, 1942–43, I, 335; Berkill, II, 1683).

Peepal—see *Ficus*

PEGANUM Linn. (*Zygophyllaceae*)

A small genus of perennial herbs distributed in the Mediterranean region, Asia and Mexico. One species occurs in India.

P. harmala Linn. HARMAL, SYRIAN RUE,

FOREIGN HENNA, WILD RUE

D.E.P., VI (1), 124; Fl. Br. Ind., I, 486; Coventry, III, Pl. 21.

HINDI—*Harmal, isband-lahouri, lahouri-hurmul*; BENG. & KASHMIRI—*Isband*; MAR.—*Harmala*; GUJ.—*Harmal, ispun*; TEL. & KAN.—*Sima-goranta*; TAM.—*Simaiyarakandi, simaiyalavina*.

A bushy herb, 30–90 cm. high, found in Ladakh and Kashmir, up to 1,650 m., and in Punjab, upper Gangetic plain, western Bihar, Rajasthan, Gujarat,



Bot. Surv. India

FIG. 124—PEGANUM HARMALA—FLOWERING BRANCH

Deccan and Konkan. Leaves multifid: segments linear, acute, narrow; flowers white, solitary in the axils of branches; capsules globose, depressed above, deeply lobed; seeds many, angled, flat.

The dried seeds of the plant constitute the drug Harmal, used in India for various medicinal purposes. The seeds (2.5–4.0 mm. x 1.5–3.0 mm.) are of a dull, earthy-brown colour with a reticulated seed coat, having a bitter taste and, when crushed, a heavy, narcotic odour. The seeds as found in the bazaar are usually mixed with capsules (I.P.C., 200; Parsa, *Qualit. Plant. Mat. Veg.*, 1960, 7, 87; Chopra, 1958, 368).

The therapeutic value of *P. harmala* is attributed to the presence of alkaloids which occur in varying amounts in seeds, roots, leaves, flowers, stems, bark and wood. Dried ripe seeds contain 3.8–5.8% alkaloids concentrated mainly in the coat; roots contain over 3%, bark 2.2% and wood 1.06%. Table 1 gives the alkaloids that have been separated from *P. harmala*. Seeds contain harmine, harmaline, harmalol

TABLE I—ALKALOIDS OF PEGANUM HARMALA*

Alkaloid	Formula	m.p.
<i>Harman alkaloids</i>		
Harmine	C ₁₁ H ₁₁ ON ₂	266°
Harmaline (dihydroharmine)	C ₁₁ H ₁₄ ON ₂	239–40° decomp.
Harmalol	C ₁₁ H ₁₃ ON ₂ .3H ₂ O	212° decomp.
<i>Quinazoline derivatives</i>		
dl-Vasicine (peganine)	C ₁₁ H ₁₁ ON ₂	198° decomp. 211–12° (vac.)
2, 3-Trimethylene-4-quinazolone†	C ₁₁ H ₁₀ ON ₂	109.5–10.5°
l-2, 3-(α -hydroxytrimethylene)-4-quinazolone†	C ₁₁ H ₁₀ O ₂ N ₂	203–04°

* Henry, 488–89, 617; † *Chem. Abstr.*, 1958, **52**, 9163, 18501.

and vasicine, with the first two predominating; roots and in smaller amounts stems also contain these alkaloids, mainly harmine. The first three, known as harman alkaloids, are closely related and contain an indole nucleus, while vasicine is a quinazoline derivative; harmalol can be prepared from harmaline by hydrolysis, whereas harmine yields harmol (C₁₁H₁₀ON₂, m.p. 321°). Harmine is present in most parts of the plant. Vasicine has been isolated in *l*-form from flowers and stems. 2,3-T trimethylene-4-quinazolone and *l*-2,3-(α -hydroxytrimethylene)-4-quinazolone were extracted from the aerial parts of the plant, along with *dl*-vasicine and harmine (Henry, 488, 617, 619; Manske & Holmes, II, 393; Allen, VII, 163; Hoppe, 648; Muenscher, 134; *Chem. Abstr.*, 1960, **54**, 9203; 1961, **55**, 16913; 1958, **52**, 9163, 18501).

An examination of the seeds from Pakistan showed the presence of a new alkaloid, provisionally named harmidine (C₁₁H₁₁ON₂, m.p. 257–58°; yield, 1.7%); the seeds contained also harmine (0.8%) and vasicine (0.1%) but no harmaline. Recently, however, harmidine has been shown to be identical with harmaline (Siddiqui, *Pakist. J. sci. industr. Res.*, 1962, **5**, 207; Robinson, *Chem. & Ind.*, 1965, 605).

In warm-blooded animals, seeds as well as the harman alkaloids cause a primary stimulation of the motor tracts of the cerebrum, and probably also of the spinal cord, giving rise to tremors and clonic convulsions; toxic doses lead to a depression of the central nervous system, with motor weakness, failing respiration, low blood pressure (due largely to the weakness of the heart muscle) and fall of temperature. Harmine and harmaline are apparently responsible

for the convulsive effects, harmalol causing a progressive paralysis of the central nervous system without initial stimulation. The alkaloids exhibit much similarity of action with quinine. They stimulate the contraction of uterus and are toxic to several of the lower forms of animal life, particularly helminths and protozoa; as a vermifuge, harmine is stated to be the most active. Against *Mycobacterium tuberculosis*, harmine is reported to be 36 times as active as *p*-aminosalicylic acid. The alkaloids were ineffective as contact insecticides but were active in vapour form (U.S.D., 1955, 1797; Henry, 496–97; Chopra, 1958, 368–70; *Chem. Abstr.*, 1938, **32**, 1327; 1956, **50**, 12312; 1961, **55**, 16913).

Harman alkaloids and their derivatives have been suggested for use as protozoicidal agents, coronary dilators and ecbolics, and in nervous diseases, e.g. post-encephalitic conditions. Harmine hydrochloride may be used as a fluorescent indicator in quantitative analysis; in acid solution, it shows an indigo-blue fluorescence which becomes yellow-green in alkaline solution. Vasicine produces broncho-dilation and may be used clinically as an expectorant (Henry, 496, 620; Manske & Holmes, II, 394).

Seeds of the plant are considered anthelmintic, narcotic, alterative, lactagogue, antispasmodic, hypnotic, anodyne, and emetic, and are used in asthma, hiccup, hysteria, rheumatism, impaction of calculus in the ureter and of gallstone in the gall duct, colic, jaundice, dysmenorrhoea and neuralgia. Seeds are used in the treatment of intermittent fevers, and against weakness of sight and retention of urine; they are considered abortifacient, and are said to have properties similar to those of ergot, savine and rue. An infusion or tincture of seeds acts as a mild emmenagogue and produces slight intoxication like *Cannabis sativa*. A decoction or tincture of seeds is used for gargle in laryngitis (Chopra, 1958, 370; Kirt. & Basu, I, 457; Nadkarni, I, 929).

Seeds are burnt as disinfectant fumigant. The smoke is used against melon flies. It is also used in wounds and painful sores, especially venereal, as a sedative (Volk, *Pakist. J. sci. industr. Res.*, 1961, **4**, 232).

Seeds have been used as a source of a red dye. They contain a soft resin with a deep carmine-like colour and a heavy narcotic odour. They yield 11.1% of an oil used in medicine. The oil extracted with petroleum ether is brownish yellow, with the following characteristics: sp. gr. 31° , 0.9163; n^{21} , 1.4725; acid val., 5.3;

sap. val., 184.5 ; iod. val. (Wij's), 120.5 ; R.M. val., 0.77 ; Polenske val., 0.45 ; and unsapon. matter, 7.3% ; fatty acid composition : palmitic, 17.87 ; stearic, 2.64 ; arachidic, 0.69 ; behenic, 0.67 ; oleic, 40.13 ; and linoleic, 38.00%. The unsaponifiable matter contains β -sitosterol and probably two hydrocarbons (m.p., 63–65° and 79–81°). The oil is suitable for soap making (Paul *et al.*, *Proc. nat. Acad. Sci. India*, 1960, **29A**, 238 : *Chem. Abstr.*, 1956, **30**, 1598).

The leaves of the plant have a disagreeable odour and a bitter taste. They contain vitamin C (80 mg./100 g.) and a small amount of a dark greenish brown essential oil. Leaves possess sudorific, emmenagogue and anthelmintic properties. A decoction of leaves is given for rheumatism. Powdered root mixed with mustard oil is applied to the hair to destroy vermin (Mensier, 433 : *Chem. Abstr.*, 1958, **52**, 20442 : 1934, **28**, 3179 ; Kirt. & Basu, I, 457).

P. harmala has been suspected of causing death of livestock in Mexico ; it is rather unpalatable and not likely to be eaten by animals under normal conditions. Experimental feeding of seeds and of alkaloids extracted from leaves caused death of guinea-pigs (Muenscher, 134 ; Chopra *et al.*, 255).

PEGIA Colebr. (*Anacardiaceae*)

Fl. Br. Ind., II, 28.

A genus of scandent shrubs distributed from North-East India to S. China and Philippines. One species occurs in India.

P. nitida Colebr. syn. *Tapiria hirsuta* Hook. f. (NEPAL—*Lahari anp, mashul, chutti lara* ; LEPCHA—*Sivong-rik, renchiling* ; ASSAM—*Dhindau bagurilata, midi-takkir, du-cheng-brup, hang-ding*) is a scandent, villous shrub with imparipinnate leaves, ovate, oblong or lanceolate leaflets, panicles of minute, white, sweet scented flowers and small, obliquely oblong, black drupes, found in eastern Himalayas and Assam up to an altitude of 1,200 m. The leaves are eaten as a vegetable. The fruits, which have sub-acidic aromatic pulp, are also eaten. The juice of the plant is reported to be applied to cuts and wounds, possibly as an anti-septic (Fl. Assam, I, 339).

PEGOLETTIA Cass. (*Compositae*)

Flower. Pl. Sudan, III, 44.

A small genus of shrubs, sometimes sub-herbaceous annuals distributed mostly in countries of Africa, western Asia and Java. One species, *P. senegalensis* Cass., a branched odorous herb with linear, entire or slightly toothed leaves and yellow or purplish

flowerheads, has been recorded in the desert regions of Rajasthan. The plant is useful as fodder for sheep and camels. It is used also for washing ornaments. As a drug it is given with ghee to children to make them strong. It is boiled and the juice is applied to wounds of camels (Blatter & Hallberg, *J. Bombay nat. Hist. Soc.*, 1918–21, **26**, 534 : Burkitt, 1909, 39).

PELARGONIUM L'Herit. (*Geraniaceae*)

A large genus of herbs, shrubs or undershrubs distributed chiefly in South Africa, and a few in tropical Africa, Syria and Australia. A number of species have been introduced into India and grown in gardens, some of which are found to run wild about the Nilgiri hills.

Commonly known as Geranium, which has no relation to the botanical genus *Geranium*, the plants are largely grown for ornamental purposes : some of the species are aromatic and cultivated for their volatile oil (Geranium Oil). Most of the garden geraniums are of hybrid origin and are grouped into Zonal, Ivy-leaved, Show, Fancy and Scented-leaved geraniums, derived from various *Pelargonium* spp. The Zonal and Ivy-leaved geraniums include numerous types with single and double flowers ranging in colour from scarlet to purple and white. Show and Fancy geraniums are used by florists for decorative purposes, but they last for a short time only. Scented-leaved geraniums are grown primarily for the delicious fragrance of their leaves used in perfumes, cookery and pot-pourri (Chittenden, III, 1510–11 : Bailey, 1949, 597 : Bailey, 1947, III, 2526–27 ; Gopalaswamiengar, 450 : Graf, 882).

Some of the geraniums grown in India are *P. zonale* Ait. and *P. inquinans* Ait. (Zonal Geranium), *P. peltatum* Ait. and *P. lateripes* L'Herit. (Ivy-leaved Geranium) and *P. capitatum* Ait., *P. graveolens* L'Herit., *P. odoratissimum* Ait., *P. quercifolium* Ait. and *P. radula* L'Herit. (Scented-leaved Geranium). Geraniums thrive and bloom well on the hills. They do not thrive well in the hot plains, especially where rainfall is heavy ; with careful management and necessary protection from hot and rainy seasons they can be grown successfully. Geraniums are propagated from cuttings and seeds (Blatter, *J. Bombay nat. Hist. Soc.*, 1930–31, **34**, 896 : Santapau, 1957, 29 : Firminger, 592 : Gopalaswamiengar, 449).

Several species of *Pelargonium* and their varieties, strains and hybrids belonging to the group of scented-leaved geraniums were previously stated as the source of geranium oil. The principal species included are :

PELARGONIUM

P. capitatum, *P. fragrans* Willd., *P. graveolens*, *P. odoratissimum*, *P. radula* and *P. terebinthinaceum* Small. Of all these species, *P. graveolens* with its varieties and strains is cultivated mainly for the distillation of the commercial geranium oil which is valued for its pronounced rose-like odour [Guenther, IV, 671-72, 676, 719, 722; Narielwala & Rakshit, *Rep. essent. Oil Comm. (Exploratory)*, Coun. sci. industr. Res., New Delhi, 1942, 16].

P. graveolens L'Herit.

Bailey, 1947, III, 2533, Fig. 2847.

A fragrant bushy plant, up to 1 m. high; leaves broadly cordate-ovate to nearly circular, deeply 5-7 lobed; each segment again lobed, toothed; flowers small, rose or pink and veined purple, in dense umbels.

P. graveolens is a native of the dry rocky slopes of Cape Province (S. Africa). It is grown chiefly in Reunion and Algeria and to a lesser extent in southern France, Spain, Morocco, Malagasy (Mada-

gascar), Congo and U.S.S.R. for the production of Geranium Oil of trade. The bulk of the world's oil supplies comes from Reunion. In India, its cultivation in c. 100 hectares has been undertaken in South India at Yercaud in the Shevaroy hills, and in the Govt. Cinchona plantations in the Nilgiris and in the Anaimalais at altitudes of 975-2,075 m. It is also grown to a small extent in the Pomological Research Station, Coonoor, and the Forest Departments, Madras and Mysore (Guenther, IV, 672-73; Gulati, *Indian Oil & Soap J.*, 1960-61, 26, 35; Swamy et al., *Indian Perfum.*, 1960, 4, 3; Menon, 13; Ramaswamy, 13).

Two types of geranium, Algerian or Tunisian and Bourbon or Reunion, are under cultivation. The former, grown in large areas in the Nilgiris, is slender with dark pink flowers and less suitable for wet conditions. The latter, grown in the Nilgiris and Anaimalais, is more sturdy with light pink flowers and more suitable to wet conditions (Swamy et al., loc. cit.; Menon, 13).

Geranium grows well in temperate, sub-tropical and tropical climates, and at various altitudes. It thrives best in sub-tropical climate. It is sensitive to frost and winter rains and can tolerate drought to some extent. It succeeds best in a porous, open and slightly calcareous soil. A reddish gravelly soil and black cotton soil are also suitable. It prefers a sheltered, warm situation. It forms an excellent cover crop and can be grown as an inter-crop in deciduous fruit orchards [Guenther, IV, 673; Krishna & Badhwar, *J. sci. industr. Res.*, 1947, 6(5), suppl., 71; Swamy et al., loc. cit.; Ramaswamy, 13-14].

It is propagated by stem cuttings raised in nursery beds or bamboo baskets. Cuttings c. 7.5-15 cm. long, with 3-5 nodes and a terminal bud, are planted in January-March in raised nursery beds (3 m. long, 90-100 cm. wide and 20-30 cm. high). They are spaced 7-10 cm. x 7-10 cm. in the beds with at least two nodes inserted in the soil. They are kept sufficiently moist and sheltered against excessive heat. Raising of cuttings in baskets is expensive and a method, comparatively cheap, has been developed which dispenses with baskets. It consists in planting the cuttings in a ball of moss, c. 8-10 cm. diam., containing a handful of jungle soil inside and tied with fibre to keep it intact. They are planted in the field with the ball intact without disturbing the root system. Application of Seradix L_{15} at the basal ends of cuttings in the form of powder for a minute is reported to induce quick rooting (Gulati, loc. cit.; Swamy et al., loc. cit.;



Director, Cinchona Dep., Ootacamund

FIG. 125—PELARGONIUM GRAVEOLENS—FLOWERING BRANCH

Kalyanasundaram, *Sci. & Cult.*, 1959-60, 25, 378 ; Chatterjee, *ibid.*, 1959-60, 25, 687).

Recently, trials have shown that propagation by root suckers and root cuttings is also possible. Propagation by single node stem cuttings is reported to be very economical [Swamy & Kalyanasundaram, *S. Indian Hort.*, 1963, 11 (3 & 4), 34].

Rooted cuttings are ready for transplanting in the field in May-July. They are planted in rows 1.2 m. apart with a spacing of 30-90 cm. between plants in rows. About 12,300 plants are required to plant in a hectare. The plantation should be hoed, weeded and irrigated where necessary. Geranium responds well to nitrogenous manures. Cow-dung, and distilled and exhausted plant materials have been used commonly in South India. Manurial experiments carried out in other countries have shown that various compositions of superphosphate, basic slag and potassium salts gave increased yield of geranium oil. A preliminary trial carried out in the Govt. Cinchona plantations with a manure mixture, containing 34 kg. of nitrogen, 44 kg. of phosphoric acid and 17 kg. of potash per hectare was found to increase yield (Swamy *et al.*, loc. cit. ; Gulati, loc. cit. ; Krishna & Badhwar, loc. cit. ; Ramaswamy, 14-15).

The roots, leaves and stumps of the plant are sometimes affected by *Fusarium* sp., *Pythium* sp. and *Rhizoctonia solani* Kuhn. The spread of the disease is checked by pruning the plant at early stage of attack. If root is attacked, the plant dies ; it should be removed and burnt. Spraying with 0.5% Bordeaux mixture controls the disease (Ranjit Singh, *Symp. essent. Oils & aromatic Chemicals, Coun. sci. industr. Res., New Delhi*, 1955, 162 ; Swamy *et al.*, loc. cit.).

The crop is harvested 8-10 months after planting when the leaves begin to turn yellow and exhibit a change from lemon-like odour to that of rose. Green leafy shoots are harvested thrice every year in July-August, October and January-March. Harvesting is done in the morning and after harvesting leaves are left in the field for 8-12 hours and then charged in the still for distillation. Average yield of leaves in various seasons is reported to be as follows: July-August, 4.050 ; October, 675 ; January-March, 2.025 kg./ha. Plants are productive for 3-6 years after reaching maturity (Swamy *et al.*, loc. cit. ; Gulati, loc. cit. ; Krishna & Badhwar, loc. cit. ; Menon, 13).

The leaves on steam-distillation yield a highly prized volatile oil, known in the trade as Oil of Geranium. The oil occurs in the plant partly free and partly as β -geranyl glycoside ($C_{10}H_{20}O_n$, m.p. 58°).

The plant material, chiefly leaves, is distilled soon after harvesting or in some places is allowed to dry in the field for sometime before charging in the still. The yield of oil varies greatly, depending upon the climatic, weather and soil conditions, altitude and age of the planting. In Reunion, freshly cut plant materials yield on an average 0.15% oil (up to 0.2%) while higher yields are obtained from material dried in the field ; dry leaves from geranium plantations in India give c. 0.17% oil. A well-maintained plantation in India gives a yield up to 17-22 kg./ha. of oil, while in a newly opened area with manuring, yields up to 33 kg./ha. have been recorded. In Reunion and Algeria yields up to 30-35 kg./ha. are known (Guenther, IV, 672-83, 695 ; Thorpe, VI, 88 ; Menon, 12 ; Ranjit Singh, loc. cit.).

A portion of the geranium crop in southern France and Morocco is extracted with volatile solvents to obtain concrete and absolute of geranium. Extraction with benzene yields 0.2-0.25% concrete, which gives 70-80% of alcohol-soluble absolute, containing 60-68% steam-distillable matter. The concrete is a pasty mass, dark green in colour, while the absolute is a thick green liquid. Both concrete and absolute possess a very fine, smooth geranium odour, softer than that of distilled oil, and more tenacious (Naves & Mazuyer, 242 ; Guenther, IV, 711).

Geranium oil is a clear, light yellow to brown liquid, with or without a green shade and possessing a strong and very pronounced rose-like odour ; some oils have a somewhat minty top note. Proper ageing of the oil for a year or two improves the odour, making it more mellow and richer. Table 1 summarizes the physico-chemical properties of geranium oil distilled in India, Reunion and Algeria. The chief constituents are geraniol and citronellol, which occur in proportions varying with the origin of oil ; substantial amounts of their esters also occur mainly with tiglic and formic acids. Besides, the oil contains isomenthone and small amounts of isoamyl alcohol, ethyl alcohol, methyl pentanol, 3-hexen-1-ol, hexanol, methyl hexyl carbinol, α -pinene, β -phellandrene, limalool, α -terpineol, menthol, borneol (?), phenyl ethyl alcohol, eugenol, sesquiterpenes, sesquiterpene alcohols and dimethyl sulphide (IS: 587-1955 ; Guenther, IV, 672, 689, 701-07).

Commercial geranium oils show differences in their odour value, depending upon the place of their origin. Algerian oil possesses a more delicate odour than that of Reunion oil, which has a slightly harsh and minty note. French oil, produced in small quantities only,

PELARGONIUM

has the finest and most rose-like odour. Citronellol content, which is highest in Reunion oil, forms the basis for the evaluation of geranium oils (Guenther, IV, 674, 702).

Geranium oil is often adulterated with geraniol and citronellol fractions derived from citronella oil (from *Cymbopogon nardus*) or with geranium oil fractions obtained as by-products in the preparation of Rhodinol. Pulegone, artificial esters, and palmarosa oil (from *Cymbopogon martini*) are other common adulterants. The oil is also liable to be adulterated with turpentine, cedarwood oil, gurjan balsam oil and fatty oils; addition of these is detected by a decrease in solubility of the oil in 70% alcohol. Cheap alcohol from rum is sometimes mixed with the oil in

Reunion (Guenther, IV, 698-700; Allen, IV, 63; Ramaswamy, 9).

Geranium oil is one of the most important essential oils, extensively used for perfuming soaps and cosmetics to which it imparts a pronounced and lasting rose odour. It blends well with all types of scents, floral as well as oriental, and forms basis for most high grade perfumes. It is largely used to adulterate otto of roses or rose attar and for flavouring tobacco products, tooth powders, ointments and other pharmaceutical preparations. Geranium oil, particularly from Reunion Island, is employed for the extraction of commercial rhodinol (a mixture of citronellol, geraniol and other alcohols) which is invaluable for the creation of perfume compounds.

TABLE 1—PHYSICO-CHEMICAL PROPERTIES OF GERANIUM OILS FROM DIFFERENT SOURCES

	Yercaud ¹	Nilgiris ²	Reunion ³	Algeria ³	Indian Standards ⁴
Sp. gr.	0.8998-0.9079 (at 15°/15°)	0.894 (at 15°)	0.8905-0.8945 (at 15°/15°)	0.8945-0.9024 (at 15°/15°)	0.8830-0.9000 (at 25°/25°)
[α] _D	..	-7.5°	-11.5° to -13°	-9.3° to -12.7°	-7° to 14°
<i>n</i> _D	1.4638-1.4708 (at 20°)	1.4712 (at 20°)	1.4630-1.4655 (at 20°)	1.468-1.472 (at 20°)	1.4600-1.4710 (at 25°)
Acid val.	7.9-10.7	3.2	up to 3.9	up to 5.6	≥13
Ester val.	..	..	62.3-72.8	54.6-74.1	†
Ester val. after acetylation	..	212.6	213.1-220.5	211.7-227.5	‡
Esters (as geranyl tiglate), %	19-22.3	23	26.2-30.7	23-31.2	17-32
Total alcohols (as geraniol), %	..	66.4	66.2-67.7	66.0-71.3	66-78
Apparent citronellol, %	..	..	43.7-52	26-40	40-55
Ketones (as isomenthone), %	..	..	6-13.5	10.5-16	≥16
Solubility in 70% alcohol	Sol. in 3 vol.	Sol. in 3 vol.	Sol. in 0.5-2 vol.	Sol. in 0.5-2.5 vol., with separation of paraffins	Sol. in 2-3 vol

¹ Ramaswamy, 18; ² Swamy *et al.*, Indian Perfum., 1960, 4, 3; ³ Guenther, IV, 688, 697; ⁴ IS: 587-1955.

† Sap. val., 40-70; ‡ Sap. val. after acetylation, 203-238.

TABLE 2—IMPORTS OF GERANIUM OIL IN INDIA

(Qty in kg. and val. in Rs.)

	Exporting countries				Total	
	France	U.K.	Netherlands	Others	Qty	Val.
1957	9,178	1,412	1,174	717	12,481	1,256,050
1958	6,927	1,056	688	570	9,241	1,140,528
1959	4,252	1,474	1,445	357	7,528	949,198
1960-61	7,550	2,080	276	471	10,377	1,516,488
1961-62	14,838	1,004	628	997	17,467	2,014,668
1962-63	8,447	114	83	316	8,960	999,760
1963-64	7,259	568	37	783	8,647	873,389

Terpeneless geranium oil is an excellent base for artificial rose ottos and is also used in floral bouquets. Concrete and absolute of geranium are used in perfumery where high odour value is desired (Guenther, IV, 707, 672; Menon, 13; IS: 587-1955; B.P.C., 1959, 324; Krishna & Badhwar, loc. cit.).

Geranium oil constitutes c. 17-20% of the total value involved in the import of essential oils of vegetable origin in India. The annual consumption of oil in the country is to the tune of c. 17,000 kg. About 1,000 kg. of oil is produced in India and the major requirements are met by imports (Table 2), chiefly from France, U.K. and Netherlands.

PELLAEA Link (*Polypodiaceae*)

Beddome, Indian Ferns, 98.

A genus of small rock-loving ferns distributed in temperate and warm temperate regions. About 8 species occur in India and a few exotics are grown as ornamentals.

P. calomelanos Link is a glabrous tufted fern with caespitose, sub-coriaceous, oblong-triangular, bi-pinnate fronds, found in north-western Himalayas at altitudes of 1,200-1,800 m.

The rhizomes of the fern are considered anthelmintic in S. Africa; a decoction of the fronds is taken for boils in the mouth and nose. The fronds are smoked for asthma and cold in the head and chest (Watt & Breyer-Brandwijk, 1087).

PELTOPHORUM Walp. (*Leguminosae*; *Caesalpiniaceae*)

A small genus of trees distributed in the tropics. One species occurs in the Andaman Islands and is cultivated elsewhere in India; one or two species have also been introduced in some Indian gardens.

P. pterocarpum Backer ex K. Heyne syn. *P. roxburghii* Degener; *P. inerme* Naves; *P. ferrugineum* Benth.

COPPER POD, RUSTY SHIELD BEARER

Fl. Br. Ind., II, 257; Corner, I, 398; II, Pl. 108.

TEL.—*Kondachinta*; TAMI.—*Ivalvagai*, *perungondrai*.

A handsome tree, up to 24 m. in height, found in coastal forests of the Andaman Islands and grown in many parts of India for its ornamental value. Bark grey, smooth; leaves bipinnate; leaflets many, small, obliquely oblong, deep green; flowers in large, erect, terminal panicles, yellow, fragrant; pods flat, winged, 5-10 cm. long, reddish brown; seeds 1-5, oblong, flattened, brownish.

The tree has a spreading shady crown and looks very attractive with contrasting clusters of yellow flowers and reddish brown pods. It is one of the most ornamental of tropical trees suited for growing in gardens, on the roadside and for shade in coffee and cocoa plantations. It can be propagated by seeds or cuttings; germination of seeds takes several months and may be hastened by softening them by immersion in dilute acid or in boiling water for two minutes. The tree has a fast rate of growth and is a good wind-break. It is reported to serve as a host of the lac insect (Corner, I, 398-99; Bentall, 168; Use of Leguminous Plants, 230; Burkill, II, 1686; Kapur, J. Bombay nat. Hist. Soc., 1954-55, 52, 645).

The bark which contains 20.8% of a catechol type of tannin and 9.5% non-tans, can be used for tanning purposes. It produces a light coloured, full and strong leather of desirable feel. Blending the bark with myrobalan (6:1) gives better results. The bark may prove a good substitute for wattle bark. Wood and leaves also contain tannin. The bark yields a dye which colours cotton yellowish brown. In Java, the bark is used in dysentery, for gargles and tooth powders and externally in lotions for eye troubles, muscular pains and sores (Varma et al., Bull. cent. Leath. Res. Inst., Madras, 1955-56, 2, 204; 1957-58, 4, 45; Burkill, II, 1687).

The heartwood is red, hard and strong and is durable when protected from weather. It is suitable for planks, coach-building, furniture and cabinet work. Sapwood, however, is soft and light and is of little use. The leaves are rich in proteins (54.7%) and can be used as a cattle feed. The leaf protein has the following amino acid composition: arginine, 5.8; histidine, 1.9; lysine, 5.4; tyrosine, 5.2; tryptophan, 2.0; phenylalanine, 5.5; cystine, 1.5; methionine, 2.0; threonine, 4.9; and valine, 7.0 g./16 g. N (Burkill, II, 1687; Cowen, 56; Bentall, 169; Kuppuswamy et al., 234).

PEMPHIS Forst. (*Lythraceae*)

Fl. Br. Ind., II, 572; Corner, I, 431, Text fig. 141.

A genus of shrubs or small trees distributed in tropical coastal regions from East Africa to the western Pacific. One species occurs in India.

P. acidula Forst. is a shrub or a small tree, up to 7.5 m. in height, with greyish brown flaky bark, small, elliptic or oblong fleshy leaves and white or pink flowers found on the coast and in backwaters of Kerala and Tirunelveli district in Madras State and in the Andaman Islands. The leaves are acidic and

PEMPHIS

edible. Wood is very hard and is used for stakes, anchors, tree nails, pestles, etc., and as fuel. Bark (tannin, 19-43%) is reported to be used locally for tanning in East Africa (Burkhill, II, 1687; Howes, 1953, 282).

Pencil Cedar, Himalayan — see *Juniperus*

Penicillin — see *Fungi*

PENNISETUM Rich. (*Gramineae*)

A genus of grasses distributed in tropical and subtropical regions of the world. About 16 species have been recorded in India, besides a few introduced from Africa and grown in experimental farms. One species, *P. typhoides*, is cultivated widely for its grain, and a few others are grown for fodder.

P. clandestinum Hochst. ex Chiov. **KIKUYU GRASS**
Fl. Assam, V, 296; Bor, 1960, 341, 344; Meredith, 444, Fig. 369 & 370.

A low, copiously branched, rhizomatous perennial, forming mats with numerous stolons having short internodes; culms usually not more than 60 cm. tall, occasionally 120 cm.; leaf 1.2-5 cm. long, sometimes up to 12 cm.; inflorescence of only 2-4 spikelets almost entirely enclosed in the leaves.

This is a native of the uplands of East Africa and has been successfully introduced into cultivation in the Nilgiris, Kodaikanal and Anaimalai hills, between 1,800 m. and 2,100 m. and in Sikkim and Assam. It is considered to be particularly suitable for moist hilly situations in India, thriving best on deep rich well-drained loamy soils at altitudes of 1,200 m. or more. Its performance has not been satisfactory in the plains. It remains dormant during winter, putting forth fresh growth with the commencement of spring. Though it cannot endure complete desiccation it will remain green during considerable periods of drought, if the reserves of moisture in the subsoil are adequate or if the roots, which are said to extend down to 3 m., can reach the water table (Whyte *et al.*, 1959, 356; Whyte, 230, 360).

The seed formation is rare and the grass is propagated by cuttings of rootstocks or runners. The best time of planting is during the spring or after commencement of rains. The cuttings are planted in furrows 90 cm. apart with 90 cm. spacing in the row. As initial growth of cuttings is slow, where rapid establishment of the grass is required for weed or erosion control, pieces of turf may be planted with 30 cm. x 30 cm. spacing. For establish-

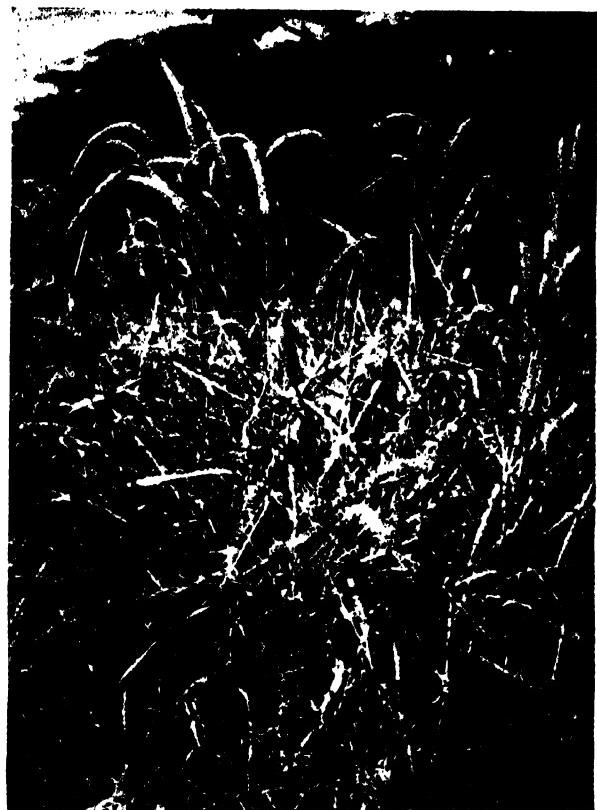
ment on hill sides, turfs are planted at 1.5-2 m. intervals on contour furrows ploughed out at 60 cm. vertical intervals. Wherever possible, the newly planted fields may be oversown with clover at the rate of c. 2.5 kg. per hectare. Early dressing of nitrogen is required in the absence of legume for establishing. The grass also responds well to dressings of farmyard manure and nitrogen applied before the onset of monsoon (Whyte, 360; Whyte *et al.*, 1959, 357).

The grass spreads vigorously by both surface and underground runners and covers the soil completely attaining a height of 75-90 cm. in a single season of 3-3½ months. Cuttings can be taken at c. 40 days' intervals giving a total yield of c. 38 tonnes per hectare per year (Whyte, 360).

Due to its dense and rapid growth, combined with hardiness, Kikuyu grass is considered suitable for improvement of hill pastures as in Sikkim, where it is said to have made spectacular strides. It has the advantage of making a reasonable growth under the shade of trees, where other grasses make a meagre growth and has been used for soiling purposes in the Nilgiris. It is reported to be very palatable to all kinds of stock including pigs and suffers no ill effect, either from close grazing or from trampling by cattle. It is not generally suitable for hay or silage and is difficult to cut and rake. The grass makes an excellent lawn giving dense soft and springy turf when closely grazed or clipped. It has been recommended for planting in poultry, as the fowls are said to like its leaves (Whyte, 360-61; Whyte *et al.*, 1959, 357; Herbert, 222; Krishnamurthi, 243).

The grass yields a nutritious fodder, rich in protein and low in fibre, when cut before flowering. Table 1 gives the chemical composition of green grass and hay. Dehydrated leaf meal contains: carotene, 25.63; riboflavin, 2.05; and niacin, 4.97 mg./100 g. (Teik, *Sci. Ser., Dep. Agric., Malaya*, No. 24, 1951, 20; Miller, 450).

The growth habit of this grass is said to make it valuable for soil conservation on hill slopes, bunds and sides of water channels, as it is able to withstand frost and water-logging. If grown near cultivated fields it may soon invade and become a troublesome weed due to its rapidity of growth. It can be controlled by application of TCA (trichloracetic acid) (Krishnamurthi, 243-44; *Mem. Dep. Agric. Madras*, No. 36, 1954, 607; Narayanan *et al.*, *Madras agric. J.*, 1959, 46, 413).



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FIG. 126 PENNSETUM ORIENTALE

	Dry matter	Protein	Fat	N-free extr.	Fibre	Mineral matter	Calcium	Phosphorus
<i>P. clandestinum</i>								
Green grass ¹ (cut before flowering)	21.0	5.1	0.4	8.4	4.9	2.2	0.049	0.075
Hay ²	93.9	10.0	3.5	43.7	21.9	14.8	..	..
<i>P. flaccidum</i>								
Green grass ³ *	..	8.7	2.2	47.2	31.9	8.9	0.48	0.18
<i>P. lanatum</i>								
Green grass ³ *	..	6.3	2.0	57.3	25.3	8.3	0.26	0.197
<i>P. orientale</i>								
Green grass ³ *	..	8.9	1.2	48.1	32.7	8.1	0.41	0.14
<i>P. polystachyon</i>								
Air-dry grass ⁴	92.6	7.3	1.6	44.8	31.2	7.6	0.40	0.113
<i>P. purpureum</i>								
Green grass ⁵	22.2	1.0	0.5	10.2	7.4	3.1	0.12	0.07
Silage ² *	..	5.8	4.9	45.9	27.5	15.9	..	..
Hay ⁶	89.1	8.2	1.8	34.6	34.0	10.5	..	..
<i>P. purpureum</i> var. <i>merkeri</i>								
Green grass ¹	20.5	2.0	0.3	9.1	6.6	2.5	0.071	0.07

^{*}Dry matter basis.¹Teik, Sci. Ser., Dep. Agric., Malaya, No. 24, 1951, 70, 78, 68, 77; ²Ramiah, Bull. Dep. Agric. Madras, No. 33, 1941, 16, 18;³Chopra et al., Indian J. agric. Sci., 1956, 26, 415; ⁴Aiyadurai, Madras agric. J., 1950, 37, 335; ⁵Lander, appx I; ⁶Morrison, 1910.

PENNISETUM

P. pedicellatum Trin.

Fl. Br. Ind., VII, 86; Bor, 1960, 346.

An annual grass with much-branched stems, 30–150 cm. high, found in Bengal, Bihar, Uttar Pradesh, Rajasthan, Gujarat, Maharashtra and Andhra Pradesh. Leaves flaccid, glabrous or sparsely hairy; spikes densely flowered, pink or purple.

This grass is found in rocky places, often sub-gregarious. It is considered to be a good fodder grass for cattle and horses. It grows well with a rainy season of 4–6 months and gives excellent yields of green fodder or hay when cut before flowering. It has been found successful in mixtures with *Phaseolus mungo* and *Melilotus indica*. It is more drought-resistant and gives higher yields than other grasses and may provide breeding material for improving leafiness of *Cenchrus ciliaris* and *P. orientale* (Whyte et al., 1959, 358; Dalziel, 537; Whyte, 292, 308–09).

P. polystachyon (Linn.) Schult. syn. *P. setosum* (Sw.) Rich.* THIN NAPIER GRASS

Fl. Br. Ind., VII, 87; Bor, 1960, 346, 348, Fig. 39.

A perennial or rarely an annual grass; culms 2 m. or more high, slender to stout; leaves linear to lanceolate 45 cm. × 3–15 mm.; spike cylindric, very dense to somewhat lax, purple, reddish brown or orange-brown.

This grass is found throughout India except in north-western parts. It has been introduced into cultivation in many areas under the name Thin or Dryland Napier grass and is said to have been so successful in the west coast, that it has become more or less naturalized in that region. It is said to be drought-resistant, suitable for cultivation under rain-fed conditions and in the poorest land. The grass is propagated by seeds. Seed viability is reduced by storage. Seeds are sown broadcast or seedlings raised in a nursery and transplanted when they are 40–60 days old and about 22 cm. tall. The first cutting can be taken after about 3–3½ months and after that a cutting can be taken every alternate month in the rainy season and then one or two more cuttings during the hot weather period. Comparative trials in Madras over a 4-year period have given an average annual yield of 18,300 kg. per hectare for Thin Napier grass as compared to 23,740 kg. and 13,750 kg. for Napier and Guinea grasses respectively. It is reported to have given a better tonnage of fodder during the



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FIG. 127—PENNISETUM POLYSTACHYON

summer months than the other two grasses. In Maharashtra, trials over a 4-year period with this grass have given annual yields of 32,200, 52,650, 43,830 and 14,520 kg. per hectare in 3–4 cuts; in Madhya Pradesh an yield of c. 65 tonnes per hectare (wet) in two cuts has been recorded. In palatability it is said to occupy an intermediate position between Napier grass and Guinea grass. Chemical composition of the grass is given in Table 1 (Krishnaswamy & Nair, *Madras agric. J.*, 1950, 37, 207; Narasimhan, *Indian Fmg.*, 1940, 1, 586; Aiyadurai, *Madras agric. J.*, 1950, 37, 335; *Mem. Dep. Agric. Madras*, No. 36, 1954, 607; Whyte, 311, 202).

P. polystachyon and some other *Pennisetum* spp. are said to be fairly self fertile and may be used as breeding material to improve the leafiness of *Cenchrus ciliaris* and *Pennisetum orientale* (Whyte, 308–09).

P. purpureum Schum. NAPIER GRASS, ELEPHANT GRASS

Fl. Assam, V, 298; Bor, 1960, 348, Fig. 40.

* Some authors consider the perennial forms as a separate species *P. setosum* (Sw.) Rich.

A robust, deep-rooted perennial grass, with a creeping rhizome, forming large clumps or stools up to 1 m. across; culms reed-like, 2-4 m. tall, 1.2-2.5 cm. in diam., sometimes branched; leaves dull green or purplish, sometimes glaucous, linear, 30-75 cm. long, with a strong midrib; spikes dense, erect, 8-30 cm. long, yellow or tinged with brown, purple or blackish purple.

This is a native of tropical Africa, introduced into India about 1912-15. It is extensively cultivated practically all over India and is popular with cattle farms, sewage farms and military farms. It is said to be variable and comprises several forms, differing in size, colour and structure of the inflorescence and its parts. There are forms with long coarse hairs at base of leaves which are said to be difficult to cut and load by hand, while there are also some which are almost glabrous [Whyte, 350; Patil & Joshi, *Indian Fmg. N.S.*, 1962-63, 12(6), 7; Meredith, 444; Whyte *et al.*, 1959, 359].

The chromosome number of *P. purpureum* is reported to be $2n=28$, while *P. typhoides* has $2n=14$. The two are said to hybridize readily with each other, giving rise to a triploid with $2n=21$ which, however, is reported to be highly sterile. One such hybrid selected at the Indian Agricultural Research Institute, New Delhi, has been released for cultivation as a fodder plant under the name *Pusa Giant Napier*. It is said to be more nutritious, succulent, palatable and responsive to nitrogenous fertilizers than Napier grass, and is reported to have given c. 279,400 kg. per hectare of fodder as compared to 135,300 kg. given by the latter (Burton, *J. Hered.*, 1944, 35, 227; Krishnaswamy, *Indian J. Genet.*, 1951, 11, 67; Raman & Krishnaswamy, *J. Indian bot. Soc.*, 1960, 39, 382; Patil & Joshi, loc. cit.).

Although the plant seeds freely, the seeds drop early and are difficult to collect. Hence the grass is propagated from stem cuttings with three to four nodes or by division of rootstocks. In sub-tropics the stems may be stored over the winter by covering in trenches. Planting is done at the beginning of the rainy season or in spring. Where winters are mild, planting under irrigation can be done at almost any time in the year, the best being from mid-February onwards. The cuttings are planted on well-prepared land, with adequate moisture, like the setts of sugarcane in furrows or they are stuck in the soil at an angle with one node buried in the soil and one above. Dibbling the rootstocks is said to be a more successful method of planting than others. About 12,500-17,500



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FIG. 128—PENNISETUM PURPUREUM (LEFT) AND ITS HYBRID WITH PENNISETUM TYPHOIDES (RIGHT)

cuttings are required to plant a hectare, depending upon the distance between plants; a higher rate is also recommended in some cases (Whyte, *World Crops*, 1950, 2, 384; Whyte *et al.*, 1959, 358; Whyte, 350-51).

As the grass is a heavy yielder it gives a ready response to manuring. About 25 to 38 cartloads of farmyard manure per hectare before planting time may be followed by an annual top dressing with 540-720 kg. of ammonium sulphate, between February and October, preferably in 3 or 4 doses. Sewage irrigation is also reported to give good response [Whyte, 351; Gandhi & Sharma, *Indian Fmg. N.S.*, 1956-57, 6(1), 8].

Once established, Napier grass continues to give fodder for a number of years, but as the productivity goes down with age, it is more economic to replant it every 5-6 years (Whyte, 351).

The first cut is generally obtained about 3 months after planting, when the plants are 1-1.2 m. tall; under proper management a cut can be obtained thereafter every 6-8 weeks. It can easily give 4-6 cuttings in a year, yielding about 50-160 tonnes per hectare, particularly with sewage irrigation. The dry

PENNISETUM

season production is said to be greatly increased by allowing the grass to reach maturity before the last wet season cut is made (Whyte, 351; Whyte *et al.*, 1959, 359; Ramiah, *Bull. Dep. Agric. Madras*, No. 33, 1941, 15; Whyte, *World Crops*, 1950, 2, 384; Gandhi & Sharma, loc. cit.).

Napier grass is valuable as silage crop. It is not particularly suitable for pasture or for hay, the culms being too woody when mature. The young herbage though readily eaten by cattle and horses is not as palatable as Guinea grass, green jowar, and green maize; mature grass becomes fibrous and loses its palatability. It is fairly nutritious (dig. protein, 0.6%; total dig. nutrients, 12.7%; nutritive ratio, 20.1) and compares well with green oats in total digestible nutrients. Table 1 gives the chemical composition of green grass, silage, and hay. The green fodder contains the following mineral constituents: calcium, 0.12; phosphorus, 0.07; potassium, 0.80; sodium, 0.10; magnesium, 0.06; iron, 0.021; sulphur, 0.03; and silicon, 0.57%. It is a good source of carotene (182-221 µg./g.) and tocopherol (195-260 µg./g.). When incorporated at a level of 5% in chick rations, Napier grass meal was as effective in maintaining the growth of the birds as lucerne meal. A nutritious silage, highly palatable to animals, can be prepared after adding molasses (2%) and salt (0.8%) (Lander, 1954, appx I, III; Nicholls & Holland, 464; Whyte, 351; Ramanujan & Anantakrishnan, *Indian J. Dairy Sci.*, 1958, 11, 101; Rosenberg, *Poul. Sci.* 1954, 33, 803; Mahadevan & Venkatakrishnan, *Curr. Sci.*, 1957, 26, 16).

When full grown, the stems are reed-like and can be used for fences, walls of huts, etc. The stems have been found to be a suitable raw material for paper making. A good quality pulp can be obtained without any difficulty, the yield (29% unbleached pulp on air-dried basis) being comparable to that from esparto grass. The length of the ultimate fibres (av. length, 2.1 mm.) is higher than those of esparto pulp and nearly equal to those of bamboo pulp. The paper obtained was tough, of good colour, fine surface taking either writing or printing ink well (Bor, 1960, 348; *Bull. imp. Inst., Lond.*, 1913, 11, 68; 1921, 19, 174; Whyte, *World Crops*, 1950, 2, 384; Whyte, 351).

P. purpureum var. *merkeri* Lecke (MERKER GRASS) is similar in habit to Napier grass, but the plants are not so tall. It is said to be more drought-resistant than Napier grass but less productive and lower in feeding value (Table 1). However, this grass as well as its

crosses with Napier grass are reported to be resistant to eye-spot (*Helminthosporium sacchari*) (Whyte *et al.*, 1959, 359; Parris & Ripperton, *Phytopathology*, 1941, 31, 855; Parris, *ibid.*, 1942, 32, 46).

P. typhoides (Burm. f.) Stapf & Hubbard syn. *P. typhoideum* Rich.* **PEARL MILLET, BULRUSH MILLET, SPIKED MILLET**

D.E.P., VI (1), 127; C.P., 869; Fl. Br. Ind., VII, 82; Bor, 1960, 350.

HINDI & BENG.—*Bajra, lahra*; MAR. & GUJ.—*Bajri*; TEL.—*Sajja, ganti*; TAM.—*Kambu*; KAN.—*Sajje*.

A tall erect annual, with slender or stout culms, 1-3 m. high, simple or branched; leaves lanceolate, 30-100 cm. x 0.5-5.0 cm.; inflorescence a false spike, compact, cylindrical, greenish yellow or with a slight pinkish tinge, varying in size from 6 to 35 cm. in length and 0.5 to 4.25 cm. in diam., densely packed with spikelets and bristles; grains pale yellow or white and from pale grey to dull light blue in colour.

The home of the pearl millet is said to be Africa from where it is said to have been introduced into India. Though none of the pearl millets are reported to occur wild, all the species closely related to the cultivated races are reported only from tropical Africa. There are divergent views about the origin and classification of pearl millets. They are held by some to have been polyphyletic in origin, some of the forms being primarily derived from one or the other of the several wild species, a few of which occur as weeds in cultivated fields, the other forms being derived by hybridization. Bajra cultivated in India, is considered to comprise forms highly improved in this way. Others consider the pearl millets to have been derived partly from the tall mesophytic *P. purpureum* (Napier Grass) and partly from the smaller xerophytic group of species of the section *Penicillaria* of the genus. Cytogenetical studies of *P. typhoides* and *P. purpureum* hybrids, however, do not bear out the view that the latter species is an ancestor of the former (Sampson, *Kew Bull. Addl Ser.*, XII, 1936, 209; Krishnaswamy, N., 1-2).

The pearl millets are considered by some authors as representing a single collective species including several races, while others designate them as distinct species. The characters by which the races vary are: height of culms, number of nodes and tillering character; hairiness and dimension of leaves; shape

* For detailed synonymy and nomenclature of this species, reference may be made to Bor, 1960, 350-51.

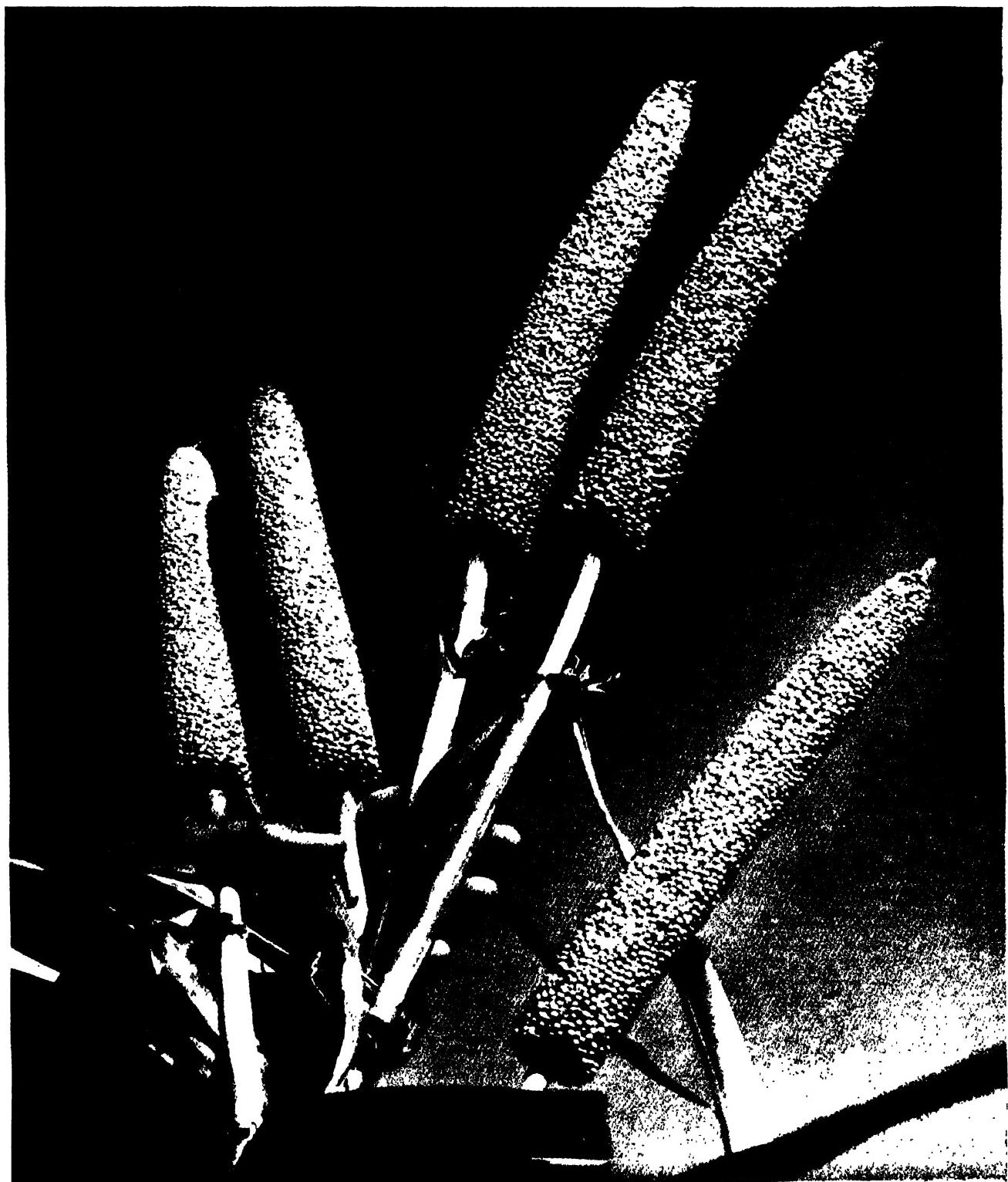


Photo : M. Ahluwalia

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PENNISETUM TYPHOIDES (PUSA MOTI) — WITH EARHEADS

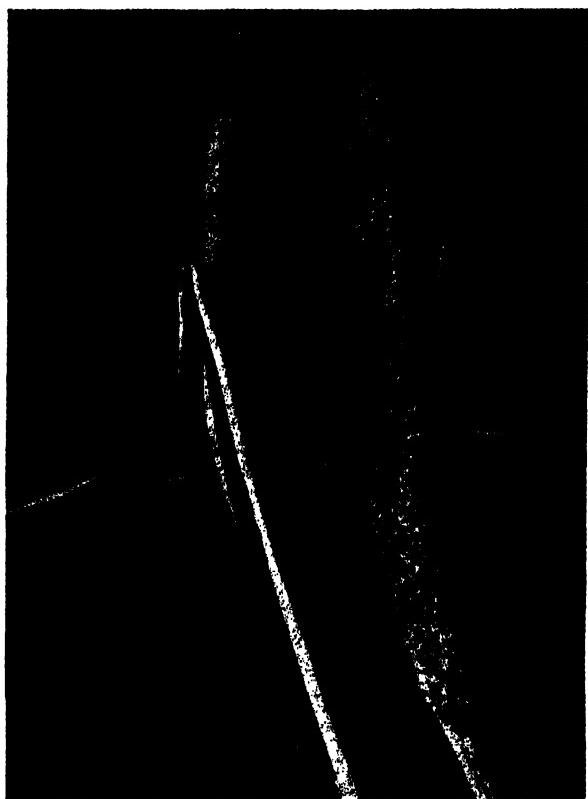
and size of the false spike or inflorescence, which may be regularly cylindrical and attain a length up to 1.4 m., or as in the majority of races, may be tapering towards the base and apex and have a much shorter length; the number, length, rigidity, fineness, hairiness and brittleness of bristles; the number of spikelets per cluster in the inflorescence; and lastly the shape, size and colour of the grains. In general, a greater variability in respect of maturity, spike and grain characters is seen amongst African types than among Indian types. Attempts are being made to incorporate some of the desirable characteristics by adopting modern methods of hybridization (Sampson, *Kew Bull. Addl Ser.*, XII, 1936, 209; Krishnaswamy, N., 10; Ahluwalia *et al.*, *Curr. Sci.*, 1963, 32, 321).

Besides India, tropical Africa and tropical Arabia are other areas where pearl millet is grown as a grain crop; it has been introduced recently to U.S.A. and other parts of the world, either as a grain crop or as a fodder crop. In India, bajra occupies the fourth place (next to rice, jowar and wheat) with a total



I.A.R.I., New Delhi. Photo: Ahluwalia

FIG. 129—PENNSETUM TYPHOIDES—VARIATION IN EARHEADS



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FIG. 130—PENNSETUM TYPHOIDES—EARHEADS WITH BRISTLES

average annual area of c. 10.7 million hectares under the crop. The area under bajra has shown a downward trend in all the major States during the past ten years (1953-54 to 1962-63), except in Rajasthan which is the most important bajra producing State, accounting for nearly 40% of the total area. The important States cultivating bajra are: Rajasthan, Gujarat, Maharashtra, Punjab, Uttar Pradesh, Andhra Pradesh, Madras, Mysore and Madhya Pradesh, which comprise among themselves more than 96% of the area under the crop (Table 2). The important districts where bajra is cultivated are: Barmer, Jodhpur, Nagaur, Churu, Jalore and Sikar in Rajasthan; Nasik, Ahmadnagar, Poona, Aurangabad, Satara and Dhulia in Maharashtra; Banaskantha, Mehsana, Bhavnagar, Surendranagar and Kaira in Gujarat; Aligarh, Agra, Etah and Budaun in Uttar Pradesh; Hissar, Mohendragarh, Gurgaon and Rohtak in Punjab; Nalgonda, Anantapur, Chittoor and Guntur in Andhra Pradesh; Tiruchirappalli, Salem, Tirunelveli, Ramanathapuram and Coimbatore in Madras; and Bijapur, Belgaum, Gulbarga and Raichur in

TABLE 2—AREA AND PRODUCTION OF BAJRA IN INDIA

	Area (thousand acres)					Production (thousand tons)				
	1958-59*	1959-60*	1960-61†	1961-62†	1962-63†	1958-59*	1959-60*	1960-61†	1961-62†	1962-63†
Andhra Pradesh	1,572	1,607	1,378	1,571	1,459	333	332	245	336	348
Bihar	17	15	16	42	46	3	2	3	8	7
Bombay	8,461	7,502	..	..	..	1,131	753	..	..	..
Gujarat	..	..	3,285	3,114	3,232	..	..	416	478	500
Maharashtra	..	..	4,174	4,255	3,964	..	..	500	432	523
Jammu & Kashmir	35	37	44	47	61	10	8	8	9	12
Madhya Pradesh	443	433	432	416	433	84	92	113	66	112
Madras	1,219	1,255	1,237	1,207	1,200	302	315	314	301	304
Mysore	1,162	1,287	1,222	1,201	1,242	110	109	125	90	128
Orissa	8	8	12	13	13	1	1	2	2	2
Punjab	2,431	2,120	2,289	2,178	2,056	278	295	290	335	321
Rajasthan	9,936	9,761	11,410	10,838	10,162	975	972	732	1,055	930
Uttar Pradesh	2,667	2,619	2,692	2,395	2,554	554	595	422	379	605
West Bengal	1	1	a	a	..	b	b	b	..	..
Delhi	47	54	..	..	..	8	10	..	..	..
Himachal Pradesh	..	..	a	a	a	..	..	b	b	b
TOTAL	27,999 (11,330)	26,699 (10,805)	28,191 (11,408)	27,277 (11,038)	26,422 (10,692)	3,789 (3,850)	3,484 (3,540)	3,170 (3,221)	3,491 (3,547)	3,792 (3,853)

* Area, production and yield per acre of forecast crops, 1949-50 to 1959-60, 11-14.

† *Agric. Situat. India*, 1962-63, 17, 1102-1963-64, 18, 720.

a—Below 1,000 acres. b—Below 1,000 tons.

Figures in brackets indicate the area in hectares and production in tonnes.

Mysore (Anderson & Martin, *Econ. Bot.*, 1949, 3, 265; Mann, *World Crops*, 1950, 2, 99; *Agric. Situat. India*, 1962-63, 17, 858; 1963-64, 18, 720).

A number of strains are grown in different States in India. In general, small-grained types from rainfed crops are preferred for human consumption as they are said to be sweeter, whereas the bold-grained types from irrigated crops are mostly reserved for fodder. In Madras, two main groups are recognized: one grown mainly under irrigation and threshing free of glumes, requiring no further husking before use, and the other grown in dry lands, with glumes adhering to threshed grain, requiring husking before consumption. Variations are also known in the duration of the rainfed crop; they are: (1) short duration types maturing in c. 80 days, suitable for regions with a short period of seasonal rain; (2) medium duration types maturing in 100 days or more, for regions with a longer period of monsoon; and (3) long duration types with a duration of 180 days or more, for regions where the rain is distributed over a reasonably long period with frequent short spurts,

when with each spurt of rain, the plants produce fresh tillers, which bear earheads serially, their harvest being done periodically as they mature. In Mysore, the three types said to be grown are: (1) type with thin stems, numerous tillers and short thin spikes, esteemed mainly as green fodder; (2) the common type with thick stem and sparse tillering; and (3) a type with highly awned spikes which renders the spikes proof against damage by birds. Studies in Madras have shown that the longer these bristles are, the greater is the shedding of the spikelets and the lesser the density of packing of the grains on the spike (Richharia, 160; Krishnaswamy, N., 10-15, 38; *Agric. Marketing India, Rep. Marketing Maize and Millets, Marketing Ser.*, No. 74, 1954, 14; Mudaliar, 159-60; Yegna Narayan Aiyer, 87; Rangaswami Ayyangar & Hariharan, *Madras agric. J.*, 1936, 24, 235).

Improved strains of bajra suitable to various regions have been evolved by selection and released for cultivation in some of the important States. Amongst them Co-1, a selection in Madras from a

short-duration African type, matures in 85 days, giving yields of 1,650-2,200 kg. per hectare and having grains with 15.5% protein content. Co-2 and Co-3 are two other selections with a duration of 90 and 80 days, yielding 660-990 kg. and 1,320-2,200 kg. per hectare respectively; the latter is reported to require irrigation. In Andhra Pradesh, AKP-1 and AKP-2 have been recommended, while for Madhya Pradesh, Gwalior-2, NB-117 and NB-119 have been found suitable. Bajri-207 is an improved type being distributed in Gujarat, while Bajri-28-15-2 and AF-3-G 1-G 1 are being distributed in Maharashtra. In Rajasthan, improved types RSK, RSJ and Churu have proved promising giving an yield of 700-800 kg. per hectare. Strain No. 16 is said to be a very popular selection in Uttar Pradesh. A-1/3, T-55 and G-61/21 are improved types from the Punjab; A-1/3 is reported to do well in Gurdaspur and Jullundur districts and yields fairly bold, roundish, slate coloured grains (yield, 1,650-1,830 kg./ha.) which are much liked; G-61/21 is also said to do well (yield, 1,350-1,650 kg./ha.) under fair rainfall or irrigation; it is a bristled type little damaged by birds. Ghana and Pusa Moti are two improved types recommended for Delhi territory,

both of them showing high yield, better and bolder grains, shorter and stiffer straw, and resistance to lodging [Krishnaswamy, N., 90; Ponnaiya & Subramaniam, *Madras agric. J.*, 1957, **44**, 380; *Mem. Dep. Agric. Madras*, No. 36, 1954, 154; Patil, *Poona agric. Coll. Mag.*, 1958-59, **49**, 265; *Rep. Marketing Maize and Millets*, 1954, 14; Roberts & Kartar Singh, 280; Joshi et al., *Indian Fmg.*, N.S., 1961-62, **11**(5), 12; Ahluwalia, *ibid.*, 1964-65, **14**(1), 4; Misra, *ibid.*, 1964-65, **14**(2), 31; *ibid.*, 1965-66, **15**(2), 40].

The diploid chromosome number of bajra is reported to be 14. Crop improvement has also been sought by utilizing hybrid vigour, as in maize, through crossing of suitable inbred races as parents. Whereas maize is monoecious, bajra is hermaphrodite; so a different technique has been adopted by making use of the male sterile lines. The desired parent lines are sown in adjacent rows, two links apart on the same day or their seeds are mixed together and sown in the same row, in the proportion of one female to three males. In general, the more diverse the geographical origin of the parents, the greater is the degree of hybrid vigour. Two such short-duration, high yielding hybrids, X-1 and X-2, are reported to give an average yield of 48 and 44 per cent, respectively, over local varieties in Madras; another hybrid, X-3 (yield up to 2,750 kg./ha.) is also reported to have been recently evolved. A high yielding hybrid has been evolved on the same lines in other States also. The disadvantage with these hybrids is that seeds have to be replaced every year. This is sought to be remedied by the evolution of synthetic varieties, which consist of six or more parent combinations. These are said to maintain their vigour for at least three generations, so that the seeds can be replaced once in every four years. Bajra has been successfully crossed with the elephant grass, *Pennisetum purpureum* ($2n=28$), and the resultant hybrid is said to be a good fodder grass. The hybrid and progeny are also rust-resistant and efforts are being made to transfer this feature to the cultivated species by means of suitable crosses [Krishnaswamy, N., 52-64; Krishnaswamy, *Indian J. Genet.*, 1951, **11**, 67; Kadain et al., *J. Hered.*, 1940, **31**, 201; *Mem. Dep. Agric. Madras*, No. 36, 1954, 154-58; Rao et al., *Madras agric. J.*, 1949, **36**, 526; 1951, **38**, 95; *Plant Breed. Abstr.*, 1956, **26**, 121; Subramaniam & Anavaradham, *Madras agric. J.*, 1959, **46**, 398; Anavaradham & Subramaniam, *ibid.*, 1961, **48**, 141; Mudaliar, 160-61; Chavan & Patil, *Poona agric. Coll. Mag.*, 1960-61, **51**(3 & 4), 1].

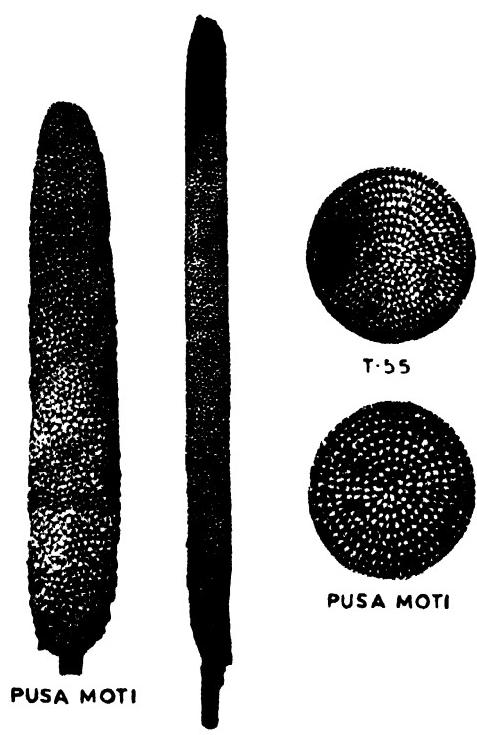


FIG. 131—PENNSETUM TYPHOIDES—EARHEADS AND GRAINS OF TWO IMPROVED TYPES

CULTIVATION

Climate & Soil—Bajra is suited to regions with a moderately dry climate and low rainfall, but requires hot temperatures to mature the crop. In general, it thrives under conditions of soil and rainfall which may not be good enough for jowar and replaces the latter in such regions. It is reported to grow in regions with rainfall ranging from 18 to 100 cm.; where the rainfall is less than 25 cm. it should be evenly distributed over the growing period. Rain at germination, flowering and harvesting is reported to be harmful [Krishnaswamy, N., 41; Mann, loc. cit.; Arakeri, *Indian Ecol.*, 1947, 2(1), 1].

Bajra can grow on a variety of soils, ranging from the heavy black soils of Andhra Pradesh, Mysore and Madras and the rich alluvial, light sandy loams of Gujarat, to the medium and light types of soils of the Deccan. In Andhra Pradesh, it is cultivated in the deltaic tracts of Godavari and Krishna. In Rajasthan, it has produced very good crops in sandy soils, when

suitable soil and moisture conservation practices were followed [*Mem. Dep. Agric. Madras*, No. 36, 1954, 153; Yegna Narayan Aiyer, 84; Chavan, *Farm Bull., Indian Coun. agric. Res.*, No. 48, 1958; Krishnaswamy, N., 41; Misra, *Indian Fmg.*, N.S., 1964-65, 14(2), 31].

Cultural operations.—In general, the soil is well prepared before sowing, though experiments conducted in Madras are said to show that this crop does not require a deep preparatory cultivation and bunding. Farmyard manure may be applied during preparatory cultivation or drilled along with the seed, at the rate of 13 cartloads per hectare in the case of dry land and 25 cartloads per hectare in the case of irrigated land. Groundnut cake at the rate of 330 kg. per hectare is reported to be applied in Gujarat, and sheep penning (c. 2,500 sheep per hectare) is said to be practised in Madras. Where the rainfall is well distributed or where irrigation facilities are available, a dose of c. 110 kg. of ammonium sulphate per hectare before



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FIG. 132—PENNSETUM TYPHOIDES—CROP WITH EARHEADS

sowing and another similar dose 3-4 weeks after sowing are beneficial. Experiments conducted in Madras are reported to show that application of ammonium sulphate at 250 kg. per hectare or groundnut cake at 550 kg. per hectare, along with 125 kg. of superphosphate increased the yield by more than 100 per cent and that it was even more profitable if applied first to cotton, residual effect on the following bajra being as high as 40 per cent over no manure. Pretreatment of the seed in cow's urine for 4 hours before sowing is said to have given significantly higher yields [Mem. Dep. Agric. Madras, No. 36, 1954, 158-59; Krishnaswamy, N., 49; Mudaliar, 161-62; Chavan, loc. cit.; Solomon & Shendge, Farmer, 1957, 8(12), 13].

Though premonsoon sowing is said to be done in some areas of Gujarat, it is done generally with the onset of the monsoon (May-August) in the different regions. In the black cotton soils of S. India, it is sown during October-November, when the North-East monsoon breaks out. Irrigated crops are sown in January-March. The seed is mostly broadcast, but sometimes drilled in rows 45-90 cm. apart. Trials in Madras are said to have given similar results for both methods of sowing. The seed rate varies from 3.3 kg. per hectare in the black soils to 9-10 kg. per hectare in other areas of Madras. Where the crop is drilled, a lower rate (3.3-4.4 kg./ha.) is reported to be sufficient. In some areas of Andhra Pradesh where the rains are well distributed, and also in the irrigated areas, seedlings raised in nurseries are transplanted. Transplanting the crop in the third week after sowing is said to have shown 35 per cent increase in yield, with a corresponding increase in straw (Chavan, loc. cit.; Krishnaswamy, N., 41; Yegna Narayan Aiyer, 84; Mudaliar, 159, 162; Patil, Poona agric. Coll. Mag., 1958-59, 49, 265; Mem. Dep. Agric. Madras, No. 36, 1954, 158; Solomon & Shendge, loc. cit.; Naidu & Rao, Andhra agric. J., 1959, 6, 76).

Bajra is grown either pure or mixed with pulses like pigeon pea, field bean, horse gram, green gram and black gram or oilseeds like sesamum and groundnut or with kenaf or mesta (*Hibiscus cannabinus*). To prevent soil erosion under dry farming conditions, kharif bajra can be grown along the contour in strips of 21 m. alternating with a suitable pulse in strips of 7 m., the bajra being sown later than the pulse depending upon seasonal conditions. Though bajra is said to be grown year after year in certain parts of S. India, it is mostly grown in rotation with one or more crops like sugarcane, wheat, jowar,

ragi, cotton, castor, groundnut, sesamum and tobacco [Chavan, loc. cit.; Krishnaswamy, N., 43; Misra, Indian Fmg, N.S., 1964-65, 14(2), 31].

In parts of Madras, the crop is thinned when it is about 3 weeks old by working the field with light ploughs; this operation also serves to remove weeds and encourage tillering. In Mysore, the field is worked with the hoe twice at an interval of 10 days, when the crop is c. 3 weeks old. In parts of Maharashtra, intercropping is done twice with the tooth harrow. When the crop attains a height of 30 cm., a plank is drawn over the crop to check its growth and encourage tillering. One or two hand weedings are also given (Mudaliar, 162; Yegna Narayan Aiyer, 85; Solomon, Bull. Dep. Agric. Bombay, No. 186, 1951, 13; Chavan, loc. cit.).

As bajra is grown mostly under dry farming conditions, water conservation is important and a wider adoption of such agronomic practices, as levelling, contour furrowing, terracing, stubble mulching and strip cropping have been recommended [Misra, Indian Fmg, N.S., 1964-65, 14(2), 31].

Diseases—The important diseases affecting this crop are the downy mildew, the rust and the smut. Other diseases affect the leaves and ears, but the damage caused is usually not much (Ramakrishnan, 67).

Green Ear or Downy Mildew, caused by *Sclerospora graminicola* (Sacc.) Schroet., is a very common disease found to cause much damage. The affected leaves turn wholly or in part white and later brown and are covered on the underside by the whitish down of sporangia. The glumes and the reproductive organs of the spikelets turn into green leafy shoots and the dense spike is transformed wholly or partially into a loose leafy head. This fungus attacks also the Italian Millet (*Setaria italica* Beauv.), but the physiologic strains infecting the two hosts are different and specific to each host. The disease being primarily soil-borne and then air-borne, development of resistant types is said to be the only way of control. A strain, T-55 (*barani bajra*), from Punjab is reported to be free from disease. In Rajasthan, RSK, RSJ, and Improved Ghana have shown resistance to this disease [Mundkur, 78-81; Uppal & Desai, Indian J. agric. Sci., 1932, 2, 667; Mem. Dep. Agric. Madras, No. 36, 1954, 1130; Ramakrishnan, 67-70; Paracer, Punjab Fmr., 1950, 2(2), 16; Misra, Indian Fmg, N.S., 1964-65, 14(2), 31].

A smut, caused by *Tolyposporium penicillariac* Bref., is reported to affect the crop at flowering time. The attack is said to be more severe in wet seasons.

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and in ears which come out during wet weather. A high incidence of infection is said to be seen in ears bagged for breeding purposes. The grains which swell and turn green at first, become black later and contain masses of spores. As the infection is air-borne, seed treatment is of no use. Rogueing and burning of smutted ears is reported to be a good preventive operation. Efforts to discover resistant types, if any, are recommended (Bhatt, *J. Indian bot. Soc.*, 1946, **25**, 163; Mundkur, 144-47; Ramakrishnan, 74-76; Patel & Desai, *Curr. Sci.*, 1959, **28**, 248).

Leaf rust, caused by *Puccinia penniseti* Zimm., is reported to be prevalent in all bajra growing States. The crop is affected at all stages of its growth under humid conditions and the leaves become completely covered by the sori and dry prematurely. Brinjal (*Solanum melongena* Linn.) and a few other *Solanum* spp. are reported to be the alternative hosts. Two races of the rust are said to have been recognized. Most of the strains of bajra being distributed for cultivation in Madras are reported to be very susceptible to this rust, but one of them, P.T. 814/3, is said to have exhibited high resistance. Some of the crosses between

bajra and *P. purpureum* are not infected by this rust while others are (Ramakrishnan & Sundaram, *Proc. Indian Acad. Sci.*, 1956, **43B**, 190; *Mem. Dep. Agric. Madras*, No. 36, 1954, 1129; Ramakrishnan, 70-74).

Leaf spot (Leaf blight or Ear blight), caused by *Curvularia penniseti* (Mitra) Boedjin syn. *Acrotheicum penniseti* Mitra, is reported to be very common in some areas of Bihar, Uttar Pradesh and Punjab. The disease appears on leaves, leaf sheath, ears and on grains in storage at high relative humidity. The initial lesions on seeds are said to appear as small dark brown spots or patches, which later surround the whole seed and these become shrunken and black in colour. No type of bajra is said to be immune. Severe infection reduces germination of seeds. Seed treated with formalin dust and mercuric chloride are reported to be free from infection (Mitra, *Mem. Dep. Agric. India, Bot.*, 1921, **11**, 57; Ramakrishnan, 77; Agarwal, *Proc. nat. Acad. Sci. India*, 1957, **27B**, 89).

Another leaf spot, caused by *Piricularia setariae* Nisikado, is reported to have been noticed on several inbred lines of the crop, some of which are reported to have been severely affected. The disease appears on the lower leaves as small, light or dark brown spots which enlarge to form darker circular spots. The disease is identified from other spot diseases on bajra by the formation of concentric rings of light brown to dark brown colour on these circular spots (Ramakrishnan, 79).

An ergot, *Claviceps microcephala* (Waller) Tul., has been reported from Bombay, the attack appearing in a severe form (up to 25% in some areas) in late-sown crops. An epidemic of ergot poisoning followed consumption of such contaminated bajra grains. The consumers suffered from nausea, vomiting, diarrhoea and marked giddiness, but recovered completely after 4-6 hours. The well-known manifestation of ergotism was not observed. The fungus infects other species of *Pennisetum* also. The fungus can survive in nature from year to year through the agency of conidia, and cool and humid weather favours infection (Bhide & Hlegde, *Curr. Sci.*, 1957, **26**, 116; Shinde & Bhide, ibid., 1958, **27**, 499; Bhide & Sheth, *Indian J. med. Sci.*, 1957, **11**, 892; Ramakrishnan, 78).

Bunt caused by *Tilletia ajirekari* Mundkur and top rot caused by *Fusarium moniliforme* Sheld. are also reported (*Indian J. agric. Sci.*, 1950, **20**, 128; *Mem. Dep. Agric. Madras*, No. 36, 1954, 1131).

Pests—The bajra crop is subject to several insect pests, many of which are common to jowar also. The Deccan grasshopper, *Colemania sphenarioides* Bol., is



FIG. 13—PENNISETUM TYPHOIDES—EARHEAD (RIGHT) AFFECTED BY SCLEROSPORA GRAMINICOLA

a serious pest in Andhra Pradesh, Maharashtra, Gujarat, Mysore and Madras. The young hoppers hatching out during June-July feed on grasses on the bunds of fields for sometime and then migrate to the cereal crop. The leaves are attacked resulting sometimes in severe defoliation. Ploughing and harrowing the field, especially along the bunds, soon after harvest is recommended to destroy the egg masses by exposure to sun. Dusting with 10% BHC at 22.4 kg. per hectare is said to give successful control (Yegna Narayan Aiyer, 87; Mem. Dep. Agric. Madras, No. 36, 1954, 932; Crop Pests and How to Fight Them, 39-41; Krishnaswamy, N., 77-78).

The red hairy caterpillar, *Amsacta albistriga* Wlk., is very destructive to the young crop so that frequent resowing may become necessary. The young caterpillars which hatch out from egg masses on the under surface of leaves of weeds or hedges thrive on them for sometime and then migrate to the cultivated crop. Removal of weeds and hedges is said to reduce severity of the pest. Handpicking caterpillars have been enforced with legislative sanction in many areas of Madras, whenever it is necessary. Infested fields may be dusted with sodium fluosilicate and inert dust, mixed in the proportion of 1:6 at the rate of 28-33 kg. of mixture per hectare. Poison baits containing 5% BIIC or DDT with wheat bran or rice husk or groundnut husk spread on infested fields at 70-80 kg. per hectare are reported to check the pest in the migrating stage (Crop Pests and How to Fight Them, 42-44; Mem. Dep. Agric. Madras, No. 36, 1954, 1032; Krishnaswamy, N., 76).

The other insect pests reported on the bajra crop are the blister beetle (*Lutta* sp.), the surface grass hopper (*Chrotogonus* sp.), and the army worm (*Cirphis unipuncta* Haw.), all of which are said to be brought under control by dusting with 5% BIIC (Crop Pests and How to Fight Them, 46-47, 41, 37; Krishnaswamy, N., 77).

The root plant parasite *Striga* causes sometimes serious loss, as much as 40%. It can be controlled by uprooting the parasites before flowering and burning them, raising catch crops, spraying with sodium chloride and potassium nitrate and application of 2, 4-D [Misra, Indian Engg. N.S., 1964-65, 14(2), 31].

Harvest & Yield—The crop is harvested when the ears are in the milk stage and if it is grown for fodder, before the stalks become too dry. Where the crop is grown in garden lands the stubbles can be ratooned and more than one cutting taken. When grown for grain, the crop is harvested when the heads are ripe.

In those types where there is considerable tillering and all the earheads do not ripen at the same time, harvesting is done in two or more stages at intervals of a week or more. These are cut off with a sickle or the whole plants are cut as near the ground as possible and dried for sometime. The stalks are stacked and the ears are threshed under the feet of cattle or by using stone rollers. Threshing is sometimes done in dewy moonlit nights and a little water is sprinkled over the earheads before threshing, to keep down the floating chaff, which may otherwise cause irritation of the skin and eyes of those engaged in the process.

The yield of bajra under dry cultivation and favourable conditions is reported to be 770-1,100 kg. and with irrigation 1,100-2,200 kg. per hectare of grain, though the average yield is much lower (Table 3). An yield as much as 3,450 kg. of grain per hectare has been obtained by a Krishi Pandit in Nasik district by following improved methods. The yield of dry fodder is about 1,320-1,650 kg. per hectare when the crop is grown for fodder only; the yield of green fodder is said to be about 22,000-27,500 kg. per hectare [Mudaliar, 160, 163-64; Yegna Narayan Aiyer, 85-86; Solomon, Bull. Dep. Agric. Bombay, No. 186, 1951, 11; Pawar, Farmer, 1957, 8(2), 17; Chavan, loc. cit.].

Storage—Bajra grain at the time of harvest contains 18-20 per cent moisture; after adequate drying it may have 12-14 per cent. Bajra in common with other millets, is stored in bulk in some areas in underground pits (capacity of up to 18,136 kg.) or in special

TABLE 3—AVERAGE YIELD OF BAJRA IN DIFFERENT STATES^a
(kg./ha.)

	1960-61	1961-62	1962-63
Andhra Pradesh	483	561	579
Gujarat	338	387	391
Madhya Pradesh	649	401	666
Madras	473	563	487
Maharashtra	302	261	336
Mysore	270	197	254
Punjab	323	386	392
Rajasthan	161	244	229
Uttar Pradesh	389	393	600
Delhi	..	144	482

^a Data from Directorate of National Sample Survey, Agric. Statist. Div., Govt. India.

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rooms ; in the markets it is stored in gunny bags in dry and well-ventilated rooms. In some areas bajra earheads are stored and threshed only when required for use. The period over which bajra can be stored is generally 5–6 months. Driage during storage is said to be c. 3 per cent. Loss due to dampness and insect attack during this period accounts for another 0.25 and 2 per cent respectively. It does not undergo any appreciable change in quality during storage but loses its lustre. It is reported to retain its viability for fairly long periods of time. Periodical sun drying of bajra stored in gunny bags is said to prevent damage by insect pests [Misra, *Indian Eng. N.S.*, 1964–65, 14(2), 31 ; *Rep. Marketing Maize and Millets*, 1954, 69–71 ; Krishnaswamy, N., 65–66].

As in the case of barley, most of the bajra grown in India is retained by the cultivators for domestic consumption ; the percentage so retained is c. 73.5 compared to 74 of barley. The important marketing centres for bajra in India are : Nellore, Anakapalle, Chittoor and Hyderabad in Andhra Pradesh ; Sangli, Karad, Ahmadnagar, Sinnar, Dhulia, Barameti, Bombay, Aurangabad, Bir, Nagpur, Akola, Yeotmal and Malkapur in Maharashtra ; Patan, Nadiad, Dessa, Amreli, Bhuj, Junagadh, Rajkot, Jamnagar, Ahmadabad and Bhavnagar in Gujarat ; Morena and Bhind in Madhya Pradesh ; Tiruchirappalli, Erode, Coimbatore and Salem in Madras ; Bellary, Chitaldrug and Bangalore in Mysore ; Rohtak, Hissar, Moga, Karnal, Dadri, Mansa and Barnala in Punjab ; Jodhpur, Ganganagar, Bandikui, Barmer, Jhunjhunu and Ajmer in Rajasthan ; and Varanasi, Gorakhpur, Ujhani (Budaun), Jaswantnagar, Hathras, Kanpur, Chandauli, Agra and Kalpi in Uttar Pradesh.

Grade specifications have not been laid down for bajra or other millets. Generally, the physical appearance of the produce being offered for sale and the amount of refraction, i.e. impurities, such as dirt, other grains, damaged, diseased, weevilled or otherwise defective grains, taken together, are taken into account by the trade. The amount of refraction is said to vary from 1.10 to 23.10 per cent in the different areas of the country (*Rep. Marketing Maize and Millets*, 1954, 61).

UTILIZATION AND COMPOSITION

Bajra serves as a staple food grain in many parts of India. It is believed to be heating and therefore in N. India, it is consumed mostly in cold weather. Bajra is a nourishing food and its nutritive value is considered to be comparable to rice and wheat. It is



Indian Coun. agric. Res., New Delhi

FIG. 134—PENNISETUM TYPHOIDES—HARVESTED EARHEADS

preferred to jowar since it is considered to have a more cooling effect. It is, however, a coarse grain and a sudden change from rice to bajra is reported to cause digestive disorders in habitual rice eaters. It is consumed mostly after husking (husk content, 8–10%) and is cooked in the same way as rice. More commonly it is ground into flour and made into cakes or unleavened bread (*chapati*). It is also made into a thin porridge. The grain is sometimes eaten after it is parched, the product (*akohi, bhunja, lahi* or *phula*) being similar to popcorn ; in some regions, the green ears are also roasted and eaten. The grain is suitable for the preparation of malt. An intoxicating drink is obtained from the malted seeds in W. Africa. Small quantities of bajra grains are used for feeding cattle and poultry. The plant is sometimes grown for green fodder. The straw is inferior to jowar and ragi and is utilized occasionally as a roughage for livestock ; it is also used for thatching and as a fuel [Kurien et al., *Food Sci.*, 1961, 10, 3 ; *Ann. Biochem.*, 1961, 21, 41 ; Solomon, *Bull. Dep. Agric. Bombay*, No. 186, 1951,

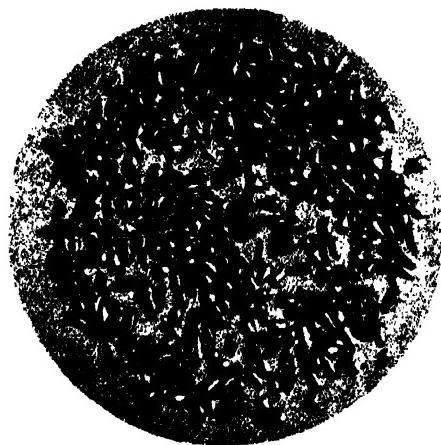


FIG. 135—PENNISETUM TYPHOIDES—GRAINS

11; Yegna Narayan Aiyer, 88; Krishnaswamy, N., 67-75; Mudaliar, 157; Irvine, 109; Chandrasekhara & Swaminathan, *J. sci. industr. Res.*, 1957, **16C**, 35; Misra, *Indian Fmg. N.S.*, 1964-65, **14**(2), 31].

Different types of bajra grains show slight variation in their chemical composition. The average chemical composition of bajra grains is as follows: moisture, 12.4; protein, 11.6; fat (ether extr.), 5.0; carbohydrates, 67.1; fibre, 1.2; and mineral matter, 2.7%; calcium, 50 mg.; phosphorus, 350 mg.; and iron, 8.8 mg./100 g. Carbohydrates consist mainly of starch with smaller amounts of sugars (1.2%), pentosans and other hemicelluloses; starch is composed of amylose (32.1%) and amylopectin (67.9%). The vitamin values of the grain are reported as follows: carotene (as vitamin A), 220 I.U.; thiamine, 282.3-450.0 µg.; nicotinic acid, 3.20-4.43 mg.; riboflavin, 188.2 µg.; and choline (as chloride), 38.2 mg./100 g. A fair proportion of thiamine occurs in combination with proteins. The percentage availability of B vitamins is as follows: thiamine, 87.2; riboflavin, 77.5; and niacin, 61.0 (Rama Rao *et al.*, *Bull. cent. Fd technol. Res. Inst., Mysore*, 1953-54, **3**, 68; Sen, *Bull. agric. Res. Inst. Pusa*, No. 70, 1917, 44; *Hlth Bull.*, No. 23, 1956, 28; Kurien *et al.*, *Ann. Biochem.*, 1961, **21**, 41; Patel *et al.*, *Sci. & Cult.*, 1958-59, **24**, 291; Chitre *et al.*, *Indian J. med. Res.*, 1955, **43**, 575; Dakshinamurti, *Curr. Sci.*, 1955, **24**, 194; Ienger *et al.*, *Ann. Biochem.*, 1955, **15**, 41; *Tech. Rep. sci. adv. Bd. Indian Coun. med. Res.*, 1951, 60).

The protein content of bajra varies from 8.8 to 16.1 per cent, of which prolamin (typhoidin) constitutes two-fifths and globulins, one-fifth; an albumin

is also reported to be present. Non-protein nitrogen forms c. 6.8 per cent of the total nitrogen. Two globulins, viz. A (coagulating at 43-45°) and B (coagulating at 83-85°), have been distinguished. The prolamin compares favourably with the prolamines of other cereals; it is characterized by a high content of tryptophan and cystine. Table 4 summarizes the amino acid make-up of the prolamin and the globulins. The essential amino acid composition of the total proteins of bajra is as follows (expressed as g./16 g. N): arginine, 6.8-8.4; histidine, 1.6-3.4; isoleucine, 4.0-5.9; leucine, 9.2-9.7; methionine, 1.7-2.4; lysine, 3.7-3.9; phenylalanine, 3.1-4.5; threonine, 2.8-4.1; tryptophan, 1.1-1.9; and valine, 4.7-6.4. Methionine is the limiting amino acid (Winton & Winton, I, 130; Abhyankar *et al.*, *Proc. Indian Acad. Sci.*, 1939, **9B**, 126; Narayananamurti & Aiyar, *J. Indian chem. Soc.*, 1930, **7**, 945; *Chem. Abstr.*, 1933, **27**, 1028; Kurien *et al.*, *Food Sci.*, 1961, **10**, 3; Swaminathan, *Indian J. med. Res.*, 1937-38, **25**, 847; Ramachandran & Phansalkar, *ibid.*, 1956, **44**, 501).

The biological value and digestibility co-efficient of bajra protein, as determined by feeding experiments on rats at 5 per cent level of protein-intake, are reported to be 83 per cent and 89 per cent respectively. At 10 per cent level of protein-intake, the protein efficiency ratio was found to be 1.43 for bajra compared to 1.2 for wheat. The growth promoting value of a poor diet (consisting of cereals or millets and pulses) based on bajra is stated to be somewhat higher than a similar diet based on wheat. Partial or complete replacement of rice by bajra in a poor vegetarian diet appreciably increased the nutritive value of the diet. The proteins of most pulses and groundnut cake possess a marked supplementary value to that of

TABLE 4—AMINO ACID MAKE-UP OF THE PROTEINS OF BAJRA*

(Expressed as % of protein)

	Prolamin (N, 15.16%)	Globulin A (N, 14.96%)	Globulin B (N, 16.21%)
Arginine	2.38	6.56	11.14
Histidine	1.55	3.89	1.12
Lysine	6.98	5.84	7.19
Cystine	2.24	3.80	2.50
Tyrosine	2.89	3.68	3.90
Tryptophan	2.07	0.95	0.79

* Abhyankar *et al.*, *Proc. Indian Acad. Sci.*, 1939, **9B**, 126.

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bajra (Swaminathan, *Indian J. med. Res.*, 1936-37, **24**, 767; Rama Rao *et al.*, *Bull. cent. Fd technol. Res. Inst., Mysore*, 1953-54, **3**, 44; *Indian J. Physiol.*, 1953, **7**, 236; Phansalkar *et al.*, *Indian J. med. Res.*, 1957, **45**, 611; Kurien *et al.*, *Ann. Biochem.*, 1962, **22**, 245).

Human metabolism studies have indicated that partial replacement of wheat by bajra in poor vegetarian diets improves the biological value of the proteins in the cereal mixture. Studies conducted on children showed that all the subjects fed on a poor diet based on bajra maintained positive balance with respect to nitrogen, calcium and phosphorus; the apparent digestibility of bajra protein was found to be c. 53 per cent, which was almost of the same order as that for the proteins of ragi and jowar, but less than that of husked rice protein (65 per cent). It was also found that 25 per cent of rice in the diet of the children could be replaced by bajra without affecting the retention of nitrogen, calcium and phosphorus (Mitra *et al.*, *Indian J. med. Res.*, 1948, **36**, 261; Kurien *et al.*, *Ann. Biochem.*, 1961, **21**, 41; *Food Sci.*, 1961, **10**, 3).

Bajra contains the following mineral constituents: calcium (29-50 mg./100 g.), phosphorus (269-391 mg./100 g.), iron (8.5-10.5 mg./100 g.), potassium, magnesium, sodium, and traces of barium, chromium, cobalt, copper, lead, manganese, molybdenum, nickel, silver, strontium, tin, titanium, vanadium, zinc, and iodine (4.5 µg./100 g.). It has been found that calcium and magnesium contents in the seed are inversely related. Phytin phosphorus constitutes 50-75 per cent of the total phosphorus. Phosphatic manures are reported to increase the phytin phosphorus and total phosphorus, while cattle manure is said to reduce them. The percentage availability of calcium and phosphorus in bajra when fed to rats, was reported as 90 and 74 respectively; in another experiment, the values found were 49.5 per cent and 54 per cent respectively. The percentage retention of phosphorus suggested that the mineral was available even from phytin; an enzyme in the intestines of the animals possibly hydrolyzed phytin phosphorus into available non-phytin phosphorus (Rao & Swaminathan, *Bull. cent. Fd technol. Res. Inst., Mysore*, 1953-54, **3**, 68; Chamberlain, *E. Afr. agric. J.*, 1955-56, **21**, 103; Shah & Mehta, *Soil Sci.*, 1959, **87**, 320; Patnaik, *Indian J. med. Res.*, 1934-35, **22**, 249; Giri, *ibid.*, 1937-38, **25**, 869; 1940, **28**, 101; Sundararajan, *ibid.*, 1937-38, **25**, 685; Ranganathan, *ibid.*, 1935-36, **23**, 229; Krishnaswamy, N., 67).

Ungerminated bajra shows negligible amylase

activity. Germination of the grains lead to a marked increase in the α -amylase activity but only a slight increase in the β -amylase activity; for both α - and β -amylases, optimum pH is 4.8 and optimum temperature 60°. Germinating grains also contain a protcinase (Chandrasekhara & Swaminathan, loc. cit.; *Chem. Abstr.*, 1944, **38**, 4280).

Bajra is sometimes infected with ergot which makes the grain toxic to human beings. The consumption of ergot-infected bajra has been reported to cause nausea, giddiness, vomiting, and diarrhoea; the patients recovered completely in 4-6 hours and no fatal cases were recorded. The alkaloid content of ergot from bajra varied from 0.3 to 0.4 per cent (calculated as ergotoxine); there are indications of the presence of ergotinine, but other alkaloids have not been distinguished. The use of infected grains as source of ergot alkaloids has been suggested (Bhide & Sheth, *Indian J. med. Sci.*, 1957, **11**, 892; Patel & Boman, *Indian J. Pharm.*, 1960, **22**, 91).

Bajra malt—Bajra is stated to be suitable for the preparation of malt and as a source of diastase. The method used involves the steeping of grains in running water for 24 hours, couching the moist grains for 72 hours at room temperature to induce germination, drying the germinated grains in the sun or in a current of hot air at 40-45°, and powdering them. The enzyme preparation can be obtained by extracting the powdered malt with distilled water. The diastase activity of bajra malt is however less than that of ragi malt (Chandrasekhara & Swaminathan, loc. cit.).

Bajra feed—Bajra grains find limited use for balancing rations for all kinds of stock, except horses, whenever possible economically. They have hard seed coats, and should be ground or softened by soaking in water before they are used. The grains are considered to be particularly useful for poultry, and for fattening cattle and lambs. Feeding trials with young bulls have shown that bajra can be profitably fed to growing animals. It has the following nutritive value: protein, 9.8; dig. protein, 4.6; and total dig. nutrients, 54.3%; nutritive ratio, 10.7. The digestibility coefficients of the grain as determined by experiments on fowls are reported as follows: organic matter, 87.2; crude protein, 87.1; ether extr., 64.2; crude fibre, 3.3; and N-free extr., 90% (Lander, 197, appx I; Das Gupta, *Indian Fmg*, 1947, **8**, 342; Mukherjee & Parthasarathy, *Indian J. vet. Sci.*, 1948, **18**, 41).

Bajra is cultivated as a valuable green fodder in many parts of India. It is well suited for this

purpose because it is quick-growing, tillers very freely, and in some types, the stems are very thin and succulent; it also lends itself to cutting more than once. It serves as an excellent green fodder when cut young, and if well cured makes a good hay. When harvested about 70 days old, it yields 22-28 tonnes of green fodder per hectare. Table 5 gives the chemical composition of the plant cut at different stages of maturity. Analysis of hay gave the following values: total dry matter, 87.2; protein, 6.7; fat, 1.7; N-free extr., 36.8; fibre, 33.0; mineral matter, 9.0; dig. protein, 4.2; and total dig. nutrients, 49.8%; nutritive ratio, 10.9 [Yegna Narayan Aiyer, 86; Misra, *Indian Fmg. N.S.*, 1964-65, 14(2) 31; Lander, 157; Morrison, 1010].

Bajra straw is utilized as an inferior fodder in more or less all the States, especially when other roughage is scarce. It is considered inferior to cereal straws and resembles ragi straw in composition. It is not relished by cattle, the stems being too coarse and pithy; it is generally used in admixture with other green feeds. However, bajra straw is a favourite cattle feed in Kaira district (Gujarat) where it constitutes over 50 per cent of the total quantity of dry fodder con-

sumed. Analysis of the straw (from Anand) obtained from summer and kharif crops gave respectively the following average values (on dry wt. basis): crude protein, 3.24, 3.45; ether extr., 1.57, 0.90; N-free extr., 44.20, 40.48; crude fibre, 36.16, 45.50; phosphorus, 0.31, 0.39; and calcium, 0.45, 0.23% [Yegna Narayan Aiyer, 86; Ramiah, *Bull. Dep. Agric. Madras*, No. 33, 1941, 10; Patel & Shah, *Indian J. agric. Sci.*, 1959, 29 (1), 19].

P. alopecuroides (Linn.) Spreng. syn. *P. compressum* R. Br. is a perennial grass with a knotty woody rhizome and strong roots, found in Naga hills in Assam, at elevations of c. 1,200-1,500 m. The grain is said to be eaten in times of scarcity. The plant is said to be used in China as tonic (Fl. Assam, V, 295; Bor, 1960, 343; Caius, *J. Bombay nat. Hist. Soc.*, 1935-36, 38, 571).

P. divisum (Forsk. ex Gmel.) Henr. syn. *P. dichotomum* Delile, a perennial grass with a bushy dichotomously branched stem, having long, rigid, smooth and polished internodes, grows on sand hills, stony ground and amongst rocks in Gujarat. It is said to be a valuable desert plant collected for fodder and relished by horses and donkeys (Blatter & McCann, 179).

P. flaccidum Griseb., found in the temperate and alpine Himalayan areas from Kashmir to western Nepal, at altitudes of 1,500-3,300 m., is a densely tufted perennial, with stem 15-60 cm. high, creeping below and branching at the base. It is attacked by two smut fungi, *Tolyposporium penicillariae* Bref. and *Sphacelotheca stewartii* Mundkur. This is reported to be a useful fodder, grazed by sheep and goats. Chemical composition of the grass is given in Table 1 (cf. p. 293) (Bor, 1960, 344).

P. hohenackeri Hochst. ex Steud. syn. *P. alopecuros* Nees ex Steud. (TAM.—*Munja pillu*; KAN.—*Nosai hullu, manmai gedde*) is a coarse perennial, with stems 60-90 cm. high, stout, erect and densely tufted, found in Rajasthan, central and western India, Mysore and Madras. It grows usually near wet or marshy places. It is sometimes affected by the ergot *Claviceps microcephala*. It is said to be used for making brooms and cordage (Blatter & McCann, 178; Bor, 1960, 344; Ramakrishnan, 78).

P. lanatum Klotzsch, found in western Himalayas from Kashmir to Garhwal, at altitudes of 2,100-2,700 m., is a perennial with a rootstock, often stout, woody, creeping and branching; stem 30-90 cm. high; leaves 15-45 cm. long. It is reported to be a valuable and abundant fodder grass and a useful soil-binder. Chemical composition of the grass is given in Table 1.

TABLE 5—CHEMICAL COMPOSITION OF BAJRA PLANT (FROM PUNJAB) CUT AT DIFFERENT STAGES OF MATURITY*

	(% moisture-free basis)				
	Just before flowering	Maximum flowering	Milk stage	Dough stage	Ripe stage
Crude protein	16.25	12.56	10.56	8.81	8.88
Ether extr.	2.03	1.97	2.12	1.86	1.74
N-free extr.	38.79	45.72	50.15	56.22	57.74
Fibre	28.23	28.45	27.96	24.90	23.96
Total ash	14.70	11.30	9.21	8.21	7.68
Calcium	0.75	0.59	0.52	0.43	0.39
Phosphorus	0.18	0.21	0.22	0.17	0.19
Magnesium	0.38	0.29	0.25	0.20	0.20
Sodium	0.34	0.044	0.14	0.18	0.096
Potassium	5.18	3.98	2.80	2.45	2.45

* Sen, *Bull. Indian Coun. agric. Res.*, No. 25, 1952, 12.

The chemical composition and nutritive value of the green plant, cut at dough stage, are as follows: moisture, 78.4; protein, 1.5; ether extr., 0.3; N-free extr., 10.6; crude fibre, 6.9; mineral matter, 2.4; calcium, 0.11; phosphorus, 0.03; potassium, 0.61; sodium, 0.052; magnesium, 0.072; iron, 0.007; sulphur, 0.056; and silicon, 0.43%; nutritive value: dig. protein, 0.9%; total dig. nutrients, 12.8%; and nutritive ratio, 12.9 (Lander, appx I, III).

PENNSETUM

Fresh grass contains traces of hydrocyanic acid ; it is said to have deleterious effects on grazing cattle, but no fatal cases have been reported. The grass may be more useful as hay, because hydrocyanic acid present is likely to be eliminated during the drying process (Bor, 1960, 345 ; Chopra *et al.*, *Indian J. agric. Sci.*, 1956, 26, 415).

P. villosum R. Br. ex Fresen. is a tufted, narrow-leaved, perennial, growing up to 50 cm. high ; inflorescence 5–10 cm. long, feathery and showy. It is a native of Ethiopia and has been introduced into this country. It is ornamental and is reported to have run wild along roadsides at Ootacamund. It is drought-resistant and may be valuable for grazing (Whyte *et al.*, 1959, 360 ; Bailey, 1947, III, 2537 ; Fl. Madras, 1793 : Bor, 1960, 352).

Pennisetum cenchroides — see *Cenchrus*

Pennyroyal, English or European — see *Mentha*

Pennywort, Indian — see *Centella*

PENTAPETES Linn. (*Stereuliaceae*)

A monotypic genus, represented by *P. phoenicea*, widely distributed in tropical Asia.

P. phoenicea Linn.

D.E.P., VI (1), 131 ; C.P., 30 ; Fl. Br. Ind., I, 371 ; Kirt. & Basu, Pl. 152.

SANS.—*Arkavallabha* ; HINDI.—*Dopahariya* ; BENG.—*Kat-lata, bandhuli* ; MAR.—*Tambdi-dupari, banduja* ; GUJ.—*Duporio, sowbhagya-sundari* ; TEL.—*Makina chettu*.

SANTAL.—*Bare baha*.

A branched herb, 60–150 cm. high, found in rice fields, marshy and wet places throughout the hotter parts of India. Leaves lanceolate, crenate-serrate ; flowers red or scarlet, solitary or in pairs on short peduncles ; capsules sub-globose, bristly ; seeds 8–12, sub-globose, dotted.

The capsule is mucilaginous and used for diseases of the bowels ; it is used in decoction as an emollient. The root of the plant is said to be astringent, and used as antibilious, antiphlegmonous and alleviative of wind and fever. The leaves are used as a tea substitute (Chandrasena, 50 ; Quisumbing, 606–07 ; Nadkarni, I, 932).

*PENTAPTERYGIUM Klotzsch (*Vacciniaceae*)

Fl. Br. Ind., III, 449.

* Some authors reduce this genus to *Agapetes* G. Don

A small genus of handsome, often epiphytic shrubs distributed in Indo-Malayan region and China. Eight species occur in India.

P. serpens Klotzsch (NEPAL.—*Harchur, kali harchu* ; LEPCHA—*Keembooten*) is an attractive, epiphytic shrub with drooping branches, elliptic-oblong leaves, bright red flowers having darker markings and turbinate-globose, 5-winged fruits found in eastern Himalayas and Khasi and Aka hills in Assam, at altitudes of 900–2,400 m. The fruit is reported to be edible (Cowan & Cowan, 80).

PENTATROPIS Wight & Arn. (*Asclepiadaceae*)

A small genus of twining herbs or undershrubs distributed in tropical Asia, Africa and Australia. Two species occur in India.

P. spiralis Decne syn. *P. cyananchoides* R. Br.

D.E.P., VI (1), 132 ; Fl. Br. Ind., IV, 19 ; Kirt. & Basu, Pl. 622A.

HINDI.—*Kauathodi* ; MAR.—*Shvetakavali* ; GUJ.—*Shigaroti*.

PUNJAB.—*Ambarvel, vanveri*.

A slender climber with a thin rootstock, 30–40 cm. long, found in Punjab, Delhi, upper Gangetic plain, Rajasthan and Gujarat (Saurashtra). Leaves fleshy, ovate, lanceolate or elliptic oblong ; flowers greenish yellow in lateral umbellate cymes ; follicles lanceolate ; seeds ovate, flattened.

The sweet tubers of the plant are peeled and eaten. Dry roots are given in decoction as astringent and cooling alterative ; they are also used in gonorrhoea. The plant is bitter, acrid and emetic (Kirt. & Basu, III, 1614).

P. capensis (Linn. f.) Bullock syn. *P. microphylla* Wight & Arn. (HINDI.—*Ambarvel* ; MAR.—*Shingrota* ; GUJ.—*Shingroti* ; TEL.—*Chekurtitivva* ; TAM.—*Oopilan kodi* ; KAN.—*Uppli balli* ; MAL.—*Parpparam*) is a slender twining herb with oblong or ovate-elliptic leaves and purplish flowers found in Bengal, Orissa (Mahanadi delta), Deccan, Carnatic, Maharashtra and Gujarat. The plant is considered cooling and alterative (Kirt. & Basu, III, 1615).

PEPEROMIA Ruiz & Pav. (*Piperaceae*)

Fl. Br. Ind., V, 96.

A genus of terrestrial or epiphytic succulent herbs distributed in the warmer regions of the world, with maximum concentration in America. Over a dozen species are found wild in India and about 10 species have been introduced into the gardens.

Peperomias are valued for their ornamental foliage, and are suitable for growing in rockeries, pots and baskets. Propagation is done by cuttings, and by seed whenever available (Chittenden, III, 1524; Firminger, 382).

P. pellucida H. B. & K. is a succulent, much-branched, procumbent herb with broadly ovate-deltoid membranous leaves and laxly flowered spikes. It was introduced from South America and became naturalized in many parts of India. The herb is grown in borders and swards and for use as a vegetable in Africa (Cooke, II, 529; Burkill, II, 1963; Dalziel, 16).

The crushed leaves are used in applications for headache and fever; their juice is given in abdominal pains. In Africa, the herb forms a common ingredient of medicinal infusions used for convulsions; a warm poultice of it is applied to boils and sores. In Trinidad, the herb is a popular refrigerant for children. Aqueous extract of the leaves shows antibacterial activity against *Micrococcus pyogenes* var. *aureus* and *Escherichia coli* (Burkill, II, 1693; Dalziel, 16; Williams & Williams, 250; Masilungan *et al.*, Philipp. J. Sci., 1955, 84, 275).

P. reflexa A. Dietr. is a somewhat creeping, terrestrial or epiphytic herb with whorls of broadly ovate, obovate or orbicular leaves and densely flowered

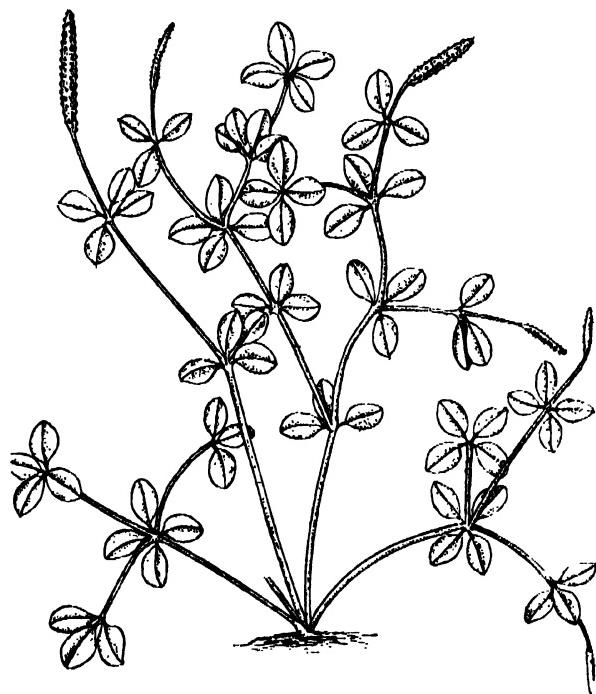


FIG. 136—PEPEROMIA REFLEXA

spikes, found from Punjab to Assam, ascending to an altitude of 2,100 m. in the Himalayas, and in the hills of Andhra Pradesh, Orissa, Madras and Kerala, usually above 1,200 m. The herb is credited with tonic properties and is used especially in kidney disorders (Fl. Assam, IV, 39).

Pepper, Bell, Bird, Cayenne, or Sweet — see Capsicum

Pepper, Black, Long, or White — see Piper

Peppermint — see Mentha

Perennial Indian Hemp — see Abroma

PERESKIA Mill. (Cactaceae)

Chittenden, III, 1526.

A genus of spiny trees, shrubs or vines, with true leaves distributed in West Indies, Mexico, Central and South America; some species are cultivated in warm countries for ornament and for their edible fruits. *P. aculeata* Mill. (BARBADOS GOOSEBERRY) and *P. grandifolia* Haw. (syn. *P. bleo* auct. non DC.) are two spiny shrubs with clambering branches, grown in Indian gardens for ornament; the latter species is also cultivated in hedges and has run wild in some places. They can be propagated by cuttings (Haines, III, 404; Gopalaswamiengar, 360; Firminger, 509).

The leaves of both the species are consumed as a vegetable; those of *P. grandifolia* are said to be used in Bihar to reduce swellings. The orange coloured berries of *P. aculeata* are acidic in taste and eaten as such, stewed or preserved. Analysis of the edible portion of the fruits gave: moisture, 91.4; protein, 1.0; fat, 0.7; total carbohydrate, 6.3; fibre, 0.7; ash, 0.6 g.; calcium, 174 mg.; phosphorus, 26 mg.; iron, trace; vitamin A, 3,215 I.U.; thiamine, 0.03 mg.; riboflavin, 0.03 mg.; niacin, 0.5 mg.; and ascorbic acid, 2 mg./100 g. (Uphof, 271; Bressers, 69; Williams & Williams, 251; Handb. Inst. Nutr. Philipp., No. 1, 1957, 30).

PERGULARIA Linn. (Asclepiadaceae)

A genus of herbaceous or shrubby twiners distributed in Africa and tropical Asia. Some species have been transferred to the genus *Telosma*. Two species occur in India.

P. daemaria (Forsk.) Chiov. syn. *P. extensa* N. E. Br.; *Daemaria extensa* R. Br.

D.E.P., III, 3; Fl. Br. Ind., IV, 20; Kirt. & Basu, Pl. 623.

SANS.—*Phala kantaka, uttaravaruni, yugma*

PERGULARIA

thalika; HINDI—*Utranajutuka, sagovani, jutuk*; BENG.—*Chagul bati*; MAR.—*Utarni*; GUJ.—*Amara-dudheli, nagaladudhi*; TEL.—*Dushtupa tige, jittupaku, gurtichettu*; TAM.—*Utthamani, veliparutti, nandamani*; KAN.—*Juttuve balli, hala koritige, talayarana balli*; MAL.—*Veliparatti*; ORIYA—*Uturdi*.

PUNJAB—*Karial, silai, trotu*.

A foetid-smelling laticiferous twiner found in the plains throughout the hotter parts of India, ascending to an altitude of c. 1,000 m. in the Himalayas. Leaves broadly ovate or deeply cordate; flowers in axillary, long-peduncled, umbellate or corymbose clusters, greenish yellow or dull white, tinged with purple; follicles lanceolate, long-pointed, covered with soft spines.

The plants are said to be browsed by goats. The leaves and flowers are eaten. An aqueous extract of the leaves shows antibacterial activity against *Micrococcus pyogenes* var. *aureus* and *Escherichia coli*. The stems yield a fibre said to be strong and useful as a substitute for flax in fishing lines. The latex of the plant examined for rubber gave on analysis: total

solids, 32.75; alcoholic extr., 25.70; chloroform extr., 0.31; and residue, 6.86% (Haines, IV, 552; Dalziel, 389; George et al., *J. sci. industr. Res.*, 1947, 6B, 42; Budhiraja & Beri, *Indian For. Leafl.*, No. 70, 1944, 17).

The vine is credited with emetic, expectorant and anthelmintic properties. The leaves have a peculiar odour; a decoction of the leaves is given to children for asthma and their juice in infantile diarrhoea. Fresh leaves made into pulp are applied to carbuncles and their juice used in the treatment of catarrhal affections. Combined with lime, leaf juice is applied to rheumatic swellings. Leaf juice is also used in the preparation of a purgative medicinal oil given in rheumatism, amenorrhoea and dysmenorrhoea. The root bark is also used as a purgative in rheumatic cases (Kirt. & Basu, III, 1616-17; Dalziel, 388).

The plant extract is used for uterine and menstrual troubles and to facilitate parturition. It has a stimulating action on uterine and other involuntary muscles, simulating that of pituitrin in many respects; the increased muscular tone produced by the extract is, however, sustained at a lower level, but its effect is more natural. Pituitrin acts with equal intensity on both the upper and lower uterine segments, while the plant extract induces earlier and well-marked contraction of the upper uterine segment as in normal labour; the action of the extract remains unaffected by progesterone which inhibits the effect of pituitrin. Administration of extract causes rise in arterial blood pressure, increase in movement and tone of the urinary bladder, and stimulation of gastric secretions. The smooth muscles of the intestines are stimulated, and the action is particularly noticeable in paralytic ileus (Chopra, 1958, 330-31).

The musculotropic activity of the plant extract, formerly attributed to a bitter glucosidic principle, is due to the presence of a polypeptide in combination with betaine. The plant also contains hentriacontane, lupeol, α - and β -amyrins, β -sitosterol, two new sterols, viz. 5β -stigmast-7(8)-en-3 α -ol (m.p. 163°) and 5β -stigmast-8(14)-en-3 α -ol (m.p. 154°), and three unidentified sterols (m.p. 141°, 151° and 160°). A more recent examination of the plant showed the presence of several cardenolides in the seeds and stems; calactin ($C_{29}H_{40}O_9$, m.p. 270-72°), calotropin ($C_{29}H_{40}O_9$, m.p. 234-40°) and calotropagenin ($C_{23}H_{32}O_6$, m.p. 248-55°) were identified in the seeds, and uzarigenin ($C_{23}H_{34}O_4$, m.p. 244-58°) and coroglaucigenin ($C_{23}H_{34}O_5$, m.p. 248-56°) in the stems. In addition to these, a number of unidentified cardenolides were isolated from the extracts of the seeds and stems



FIG. 137—PERGULARIA DAEMIA—FLOWERING AND FRUITING BRANCH

(Dutta & Ghosh, *Indian J. Pharm.*, 1947, **9**, 58 ; Rakhit et al., *J. sci. industr. Res.*, 1959, **18B**, 422 ; Mittal et al., *Helv. chim. acta*, 1962, **45**, 907 ; Heilbron & Bunbury, I, 605).

Pergularia spp. — see *Telosma*

PERICAMPYPLUS Miers (*Menispermaceae*)

D.E.P., VI (1), 139 ; Fl. Br. Ind., I, 102.

A genus of climbers distributed in the Indo-Malaysian region. Two species occur in India.

P. glaucus (Lam.) Merrill syn. *P. incanus* Miers (HINDI & BENG.—*Barakkanta* ; MAL.—*Malathangi* ; NEPAL & LEPCHA—*Pipal-pati, lahara* ; ASSAM—*Goria-loti*) is a slender woody climber with sub-orbicular or broadly ovate leaves, small yellowish green, fragrant flowers and obovoid, red drupes. It is found chiefly in the hill forests of Sikkim, northern Bengal and Assam and to a lesser extent in parts of U.P., Andhra Pradesh, Kerala and Nicobar Islands.

The stems are fairly strong and durable and used for basket work and for tying purposes. The fruit is bitter and is said to be used as a substitute for cubeb. The leaves yield a mucilage in water, which is employed in Moluccas for falling of hair ; pounded leaves are applied in headache. An infusion of the leaves is used also for asthma and high fever (Brown, 1941, I, 532 ; Fl. Assam, I, 52 ; Burkhill, II, 1693).

The bark contains a non-toxic bitter principle. The roots are reported to contain a narcotic alkaloid (Burkhill, II, 1694 ; Wehmer, I, 332).

PERILLA Linn. (*Labiatae*)

A genus of herbs distributed in India, Sino-Japanese region and south-eastern Asia. One species occurs in India.

P. frutescens (Linn.) Britton syn. *P. ocimoides* Linn.

D.E.P., VI(1), 140 ; Fl. Br. Ind., IV, 646 ; Mukerjee, *Rec. bot. Surv. India*, 1940, **14**(1), 85 ; Fl. Japan, Fig. 499 & 500.

HINDI—*Bhanjira* ; BENG.—*Ban tulsi*.

ASSAM—*Arim, angami, kenia* ; KUMAUN—*Jhutela*.

An aromatic, bushy annual, up to 150 cm. in height, found almost throughout the Himalayas up to an altitude of c. 3,500 m. and in the hills of Assam and Bihar. Leaves broadly ovate, acuminate, coarsely serrate or crenate ; flowers small, white in axillary and terminal racemes ; nutlets, commonly called seeds, rounded, pale brown, with reticulate markings, weighing c. 250 to a gram.

The herb is cultivated in some Asian countries,

particularly in China and Japan, for its seeds which yield a drying oil of commercial importance. Experimental plantings in U.S.A. have not shown much success, but encouraging results have been obtained in South Africa. In India, the plant is frequently grown in the Himalayas and Assam by the local people, but there is no organized cultivation of the herb. *P. frutescens* var. *crispa* Decne. ex Bailey syn. *P. nankinensis* Decne., a variety with ornamental bronzy-purple leaves, is grown in the gardens. *P. frutescens* var. *crispa* forma *viridis* Makino is cultivated in Japan for the extraction of a commercially important volatile oil from its leaves and flowering tops (Guenther, III, 688).

P. frutescens grows well in sandy loam. The seeds are sown in rows, c. 60 cm. apart, at the rate of about 5–7 kg./ha. When the seedlings are nearly 3 cm. high they are thinned out to 7–10 cm. apart. The plants flower after 5 months or so and bear seeds a month later. Difficulty is encountered in collecting the seeds as all of them do not ripen simultaneously and drop off shortly after ripening. The yield of the seeds in Japan is up to 1,680 kg./ha. (Bull. imp. Inst., Lond., 1920, **18**, 479 ; Schery, 332).

The leaves and flowering tops are used as flavourings. The herb is reported to possess sedative, anti-spasmodic and diaphoretic properties and is prescribed for cephalic and uterine troubles. *P. frutescens* var. *crispa* is used in mixtures administered for cough and lung affections. Its leaves are used in Japan for colouring plum preparations : they contain an anthocyanin, perillanin chloride ($C_{20}H_{24}O_4Cl$), which on hydrolysis yields probably delphinidin, protocatechuic acid and glucose (Caius, *J. Bombay nat. Hist. Soc.*, 1940-41, **42**, 411 ; Burkhill, II, 1694 ; Barksdale, *Gdn J., N.Y.*, 1962, **12**, 93 ; *Chem. Abstr.*, 1931, **25**, 3997).

P. frutescens yields 0.3–1.3% (dry wt. basis) of a volatile oil having the following characteristics: d^{20} , 0.990 ; n_{D}^{20} , 1.4865 ; $[a]_{D}^{20}$, -0.74° ; acid val., 2.69 ; sap. val., 78.01 ; ester val., 75.32 ; and citral content, 20%. The oil and citral contents are maximum at the beginning of flowering. The oil does not contain perillaldehyde, the essential constituent of the commercial oil from *P. frutescens* var. *crispa* forma *viridis* (q.v.) (*Chem. Abstr.*, 1957, **51**, 8380, 3934 ; Guenther, III, 688).

The seeds are edible. They contain: moisture, 6.30 ; protein, 23.12 ; fatty oil, 45.07 ; N-free extr., 10.28 ; crude fibre, 10.28 ; and ash, 4.64%. Presence of nicotinic acid (3.98 mg./100 g.) and a substance

PERILLA

having antioxidant activity is also reported. The essential amino acid composition of the seed protein is as follows (g./16 g. N): arginine, 14.8 ; histidine, 2.5 ; leucine, 6.3 ; isoleucine, 4.3 ; lysine, 4.4 ; methionine, 1.4 ; phenylalanine, 5.1 ; threonine, 3.0 ; and valine, 6.0 (*Chem. Abstr.*, 1930, **24**, 4413; Sen Gupta, *Indian J. appl. Chem.*, 1958, **21**, 45; *Chem. Abstr.*, 1958, **52**, 7739; Smith *et al.*, *Econ. Bot.*, 1959, **13**, 132).

Perilla Oil—The seeds of *P. frutescens* contain 30–51% (av. 38%) of a valuable drying oil known as Perilla Oil. A similar oil is obtained from the seeds of *P. frutescens* var. *crispa*, but it is not of much commercial importance. Perilla oil is recovered by expression or solvent extraction of the roasted seeds. It is produced in Manchuria, Japan, Korea, China and E. Indies, and to a small extent in North India. The raw oil contains mucilaginous matter and is refined by coagulating the break by heating, allowing to settle, and finally filtering. The oil may be refined also by alkali treatment (Eckey, 732–33; Schery, 332; Chatfield, 34–35).

The crude oil is deep yellow or greenish, whereas the refined oil is light yellow in colour. The oil has a pleasant smell and resembles linseed oil in appearance, composition and general behaviour. The characteristics of the oil generally fall within the following ranges: sp. gr.^{15°}, 0.930–0.937; n_{D}^{20} , 1.480–1.482; acid val., 1–6; sap. val., 189–97; iod. val., 193–208; and unsapon. matter, 0.6–1.3%. The composition of the fatty acids is as follows: saturated, 3.5–7.6; oleic, 3.9–13.8; linoleic, 33.6–59.4; and linolenic, 23.3–49.0%. Higher content of linolenic acid up to 70% has been found in some samples of oil. The seeds collected from Manipur hills yielded 46% of oil with the following constants: sp. gr., 0.934; acid val., 5.1; sap. val., 194.7; and iod. val., 193 (Jamieson, 290; Eckey, 733; Heaton, 227; Chatfield, 34; Hilditch, 1956, 173; Warhadpande, *Industry, Calcutta*, 1952–53, **43**, 300).

The iodine value of perilla oil is exceptionally high for a drying oil: a value as high as 260 has been recorded for a sample. Its drying properties lie between those of tung and linseed oils. It dries in about two-thirds of the time taken by linseed oil, giving a film which is glossier, tougher and harder than linseed oil film. The raw oil, however, tends to form globules leading to the development of streaks in the paint films; heating of the oil at 270° for a short time removes this tendency. Stand oils can be readily obtained from refined perilla oil; since the oil has a low flash point (215°), it should be heat-treated

with care. Perilla stand oil is superior to linseed stand oil, with greater durability and resistance to water; in stove finishes, it dries tougher and yields films with excellent surface hardness. The chief drawbacks of perilla oil are its yellowing on stoving and on exposure, tendency to surface-dry, resulting in rivelling during stoving, and lack of flexibility in the stoved films (Chatfield, 35–36; Allen, II, 201; Thorpe, IV, 84; Brady, 607).

Perilla oil finds extensive use in paints and varnishes, core oils, printing inks, Japanese oil papers, waterproof cloth, artificial leather, cheap lacquers, enamels and linoleum. It provides better printing ink media than linseed oil. In U.S.A., the oil is mixed with soybean oil for protective coatings. In the countries of origin, the oil is also utilized for edible purposes and for burning. The fatty acids of the oil can be used in the preparation of alkyd resins (Brady, 607; Kirk & Othmer, VIII, 395; Thorpe, IV, 84; Chatfield, 35, 269; Jamieson, 191; Hill, 196; *Chem. Abstr.*, 1941, **35**, 4615; 1930, **24**, 251).

The cake left after the expression of the oil is used in Japan as a fertilizer for mulberry and rice; it contains: calcium, 0.56; phosphorus, 0.47; and nitrogen, 6.14%. The seed cake or meal is rich in proteins and may be used as a cattle feed. The average feed value of the cake is as follows: protein, 38.4; fat, 8.4; N-free extr., 16.0; crude fibre, 20.9; dig. protein, 34.2; total dig. nutrients, 61.4%; and nutritive ratio, 0.8. The oil cake of *P. frutescens* var. *crispa* has similar composition and uses (Thorpe, IV, 84; Morrison, 500, 1060; Remington, 46).

Volatile oil of perilla—The oil is distilled in Japan from dried leaves and flowering tops of *P. frutescens* var. *crispa* forma *viridis* Makino, locally called 'Ao-Shiso'. The leaves and flowering tops are bundled and hung in sheds for drying for two weeks before being distilled. The stills used for the distillation of the oil are more or less of the same type as those employed for the distillation of mint oil. The genuine oil, obtained in yield of 0.1–0.15%, contains 40–55% of perillaldehyde (4-isopropenyl-1-cyclohexen-7-al, $C_{10}H_{14}O$, b.p. 235–37°), as its most characteristic constituent. Oil distilled from fresh plants at different stages of growth shows a gradual increase of aldehydes and a corresponding decrease of esters as the stage of flowering progresses, while the oil from dried plants shows the reverse (Guenther, III, 687–90; *Chem. Abstr.*, 1947, **41**, 3767).

The oil possesses a hay-like odour and has the following characteristics: sp. gr.^{15°}, 0.923–0.938;

[α], -73.2° to -96.5° ; n^{20} , 1.4971–1.5048; acid val., 1.0–1.5; sap. val., c. 40; sol. in 0.5 vol. or more of 90% alcohol. A high laevo-rotation is associated with a high content of aldehyde. Besides perillaldehyde, the oil contains Limonene (c. 9%) and small quantities of α -pinene and a substance (m.p. 128°) having an odour resembling that of celery and parsley (Finnemore, 801; Guenther, III, 689–90).

The volatile oil of perilla is used sparingly as a flavouring agent in table sauces, confectionery and dentifrices. It possesses a strong antiseptic action and is used as an antimildew agent. The oil is used in Japan chiefly for the preparation of the α -antialdoxime of perillaldehyde which is 2,000 times as sweet as sugar and 4 to 8 times as sweet as saccharin; the Japanese Government permits the use of this derivative as a substitute for maple sugar or liquorice in the sweetening of tobacco (Guenther, III, 691).

PERIPATUS (Phylum *Arthropoda*, class *Onychophora*)

Peripatus is a worm-like animal, 7–10 cm. long, with a soft and velvety skin, a pair each of stout antennae, eyes and horny jaws and with several pairs of legs, all alike, hollow, unjointed and bearing claws. Although over a hundred species have been reported from various parts of the world, the animal is scarce. Peripatus generally inhabits tropical forests and is sluggish, nocturnal and carnivorous, feeding chiefly on insects. The only Indian species discovered in Abor territory in Assam during 1911–12 is *Typhloperipatus williamsoni* Kemp, characterized by the absence of eyes; it was found living under stones at altitudes between 360 and 760 m. Peripatus has hardly any economic value, but is important as a connecting link between two major groups of animals, the annelid worms and the arthropods (Encyclopaedia Britannica, XVII, 523; Regan, 70; Pycraft, 189–91; Buchsbaum, 235–38; Kemp, Rec. Indian Mus., 1913, 9, 241; 1912–22, 8, 471).

PERIPLOCA Linn. (*Asclepiadaceae*; *Periplocaceae*)

A small genus of erect or twining shrubs distributed in southern Europe, Asia and tropical Africa. About seven species are recorded in India.

P. aphylla Decne.

D.E.P., VI (1), 140; Fl. Br. Ind., IV, 12; Kirt. & Basu, Pl. 619A.

PUNJAB—*Bata, barri, barrarra*.

An erect shrub, 1.8–3.0 m. high, usually leafless,

recorded only from Merwara (Rajasthan). It bears fragrant flowers, greenish outside, dark purple within, and woody, terete, follicles.

The plant is used as fodder for camels and goats and when dry, for fuel. The flower buds are sweet and eaten raw or cooked as vegetable. The leaves and stems contain 2.2% of a resin alcohol ($C_{25}H_{42}O_3$, m.p. 272.5°), a bitter substance, tannin, and small quantities of a glucosidal principle which produces first a decrease and then an increase in blood pressure. The stem is reported to yield a fibre used for making ropes (Burkhill, 1909, 48; Talbot, II, 238; Chopra et al., Arch. Pharm., Berl., 1937, 275, 192).

The milky juice solidifies on exposure to air, forming a gummy substance which can be utilized as an ingredient of chewing gum. The juice is used as an external application to tumours and swellings. The bark contains 8% tannin and a decoction of it is given as a purgative [Qazilbash, Pharm. J., 1960, 185, 497; Kirt. & Basu, III, 1602; Edwards et al., Indian For. Rec., N.S., Chem. & Minor For. Prod., 1952, 1 (2), 153].

PERISTROPHE Nees (*Acanthaceae*)

A small genus of herbs distributed in the tropics and sub-tropics of Asia and Africa. Six species occur in India.

P. bicalyculata Nees

D.E.P., VI (1), 141; Fl. Br. Ind., IV, 554.

HINDI—*Atrial*; BENG.—*Nasabhaga*; MAR.—*Ghati pitta papada, rankirayat*; GUJ.—*Kali aghedi*; TEL.—*Chebeera*; KAN.—*Cheebee gida, cheebeera soppu*.

SANTAL—*Bange khode baha*; MUNDARI—*Huring mara chuta, luputian mara chuta*.

An erect, hispid herb or undershrub, 60–180 cm. high, found in forest undergrowth, hedges and wasteland almost throughout India. Leaves ovate, acuminate, pubescent; flowers rose, purple or pink, in lax panicles; capsules pointed, narrowed into a cylindric stalk; seeds orbicular, papillose, slightly rugose.

The plant is said to be given as fodder for horses. In southern India, it is said to be used as a green manure. A yellowish brown essential oil (m.p. 33–36°), obtained by steam-distillation of the plant, shows tuberculostatic activity *in vitro*. It inhibits the growth of various strains of *Mycobacterium tuberculosis* in concentrations from 15 to 20 μ g./cc. (Dalziel, 452; Burkhill, II, 1695; Chopra & Chopra, Indian J. med. Res., 1959, 47, 161).

PERISTROPHE



FIG. 138—PERISTROPHE BICALYCULATA—FLOWERING AND FRUITING BRANCH

P. bivalvis Merrill syn. *P. tinctoria* Nees

D.E.P., VI (1), 141; Fl. Br. Ind., IV, 556.

BENG.—*Bet-rang, bhatia-rang.*

An erect spreading herb, 60 cm. high, doubtfully wild, but cultivated in Bengal and Assam. Leaves ovate, sub-acute; flowers rose or purple, axillary or terminal; capsules ellipsoid; seeds ovoid, compressed.

P. bivalvis is grown for its twigs which yield a dye ranging in colour from yellow orange to deep red orange. It has been used for colouring sticks from which *masland* mats of Midnapur (West Bengal) are made and also for dyeing fabric (Brown, 1946, III, 337; Burkill, II, 1695).

The plant can be propagated by cuttings or seeds; propagation by cuttings is preferred as growth is quicker. Cuttings planted in June–July grow to a height of about 90 cm. and flowers appear in October–November, when the twigs and the matted extremities of the branches are lopped for dyeing purposes.

The twigs, and sometimes the roots are used fresh or after drying. They are cut into small chips and

pounded; for dyeing, the pounded matter is mixed with water and boiled, and sticks of *Cyperus* sp. used for manufacture of *masland* mats, made into bundles, are dipped in this solution and boiled further for 3 hours; the bundles are then removed and dried. The sticks acquire a red colour. For dyeing cloth, the pounded matter is boiled in water for a long time; the solution is then allowed to cool and pounded alum is mixed with it. The cloth after washing in water is steeped in the above solution and dried in the shade. The steeping and dyeing are repeated 2–3 times. The cloth attains a dull red colour.

The leaves of the plant are pounded and used as poultice for skin diseases (Burkill & Haniff, *Gdns' Bull.*, 1929–30, 6, 232).

Periwinkle, Madagascar or Red—see *Lochnera*

PEROTIS Ait. (*Gramineae*)

A small genus of annual or perennial grasses found in the tropics and sub-tropics of the Old World. Two species occur in India.

P. indica (Linn.) Kuntze syn. *P. latifolia* Ait.

Fl. Br. Ind., VII, 98; Fl. Assam, V, 160; Bor, 1960, 612, Fig. 72.

TEL.—*Nakka peethu, nakka toka*; TAM.—*Narival pillu, thopparai pillu*; KAN.—*Narimisai hullu, jabburu korlai hullu*.

BOMBAY—*Kuras.*

An annual grass found throughout India, ascending up to 2,400 m. in the Himalayas. Stem sub-erect, glabrous; leaves ovate or lanceolate; spikelets tinged with purple; grain almost cylindric.

This grass is common in dry and sandy soils all over the country and is considered to be a good fodder grass, relished by stock at all stages. Analysis of the grass gave (on dry basis): moisture, 8.41; protein, 4.03; fat, 1.87; fibre, 30.56; carbohydrates, 49.41; and ash, 5.72% (Blatter & McCann, 220; Haines, V, 978; Dalziel, 540; Ramiah, *Bull. Dep. Agric. Madras*, No. 33, 1941, 14).

PEROVSKIA Karel. (*Labiatae*)

A small genus of herbs or sub-shrubs distributed from western Asia to the Himalayas and western Tibet. Two species are recorded in India.

P. abrotanoides Karel.

D.E.P., VI(1), 142; Fl. Br. Ind., IV, 652; Mukerjee, *Rec. bot. Surv. India*, 1940, 14(1), 103; Kirt. & Basu, Pl. 761A.

An erect shrub or undershrub, 60–120 cm. high, found from Kashmir westwards at altitudes of 2,400–3,900 m. Leaves linear-oblong, incised, pinnatisect or sometimes bi-pinnatisect; flowers blue or purple, in simple spike or panicle; nutlets pyriform, smooth.

The plant is eaten by camels, sheep and goats. It is used as a cooling medicine. In Iran, it is given for tenesmus and stomach acidity. The plant yields a volatile oil. A sample of the oil had the following characteristics: d_{20}^{20} , 0.9144; $[a]_D$, +9.4°; n_D^{20} , 1.4765; sap. val., 0.55; ester val., 10.7; and ester val. after acetylation, 44.54 (Parsa, *Qualit. Plant. Mat. Veg.*, 1960, 7, 88; *Chem. Abstr.*, 1934, 28, 6936).

P. atriplicifolia Benth.

Fl. Br. Ind., IV, 652; Mukerjee, *Rec. bot. Surv. India*, 1940, 14(1), 103; Chittenden, III, 1531.

A rigid herb or undershrub, 60–100 cm. high, found from Kashmir westwards at altitudes of 2,250–3,060 m. Leaves ovate or lanceolate, crenate-serrate or incised; flowers white or lavender coloured, in a simple spike or panicle; nutlets pyriform, smooth.

The plant is used as a cooling medicine. The flowers are eaten in Baluchistan. Steam-distillation of the dried flowerheads yields 1% of a light olive-green essential oil with a predominating camphoraceous aroma and the following characteristics: d_{30}^{30} , 0.8943; $[a]_D^{30}$, +8.53°; n_D^{30} , 1.4748; acid val., 0.2; ester val., 30.4; and ester val. after acetylation, 49.22. The oil contains: terpenes (d - α -pinene, β -pinene and camphene), 50%; alcohols and esters (d -borneol and bornyl acetate), 15–18%; sesquiterpenes (aromadendrene and α -caryophyllene); and acetic acid. It may be useful as a commercial source of d -borneol (yield, 8.5%). The flower-stalks give a similar oil, but in a lesser yield (0.2%) (Kirt. & Basu, III, 1994; Burkhill, 1909, 59; Rao, *J. Indian chem. Soc.*, 1926, 3, 141).

PERSEA Mill. (*Lauraceae*)

A genus of trees and shrubs distributed in North and South America, Canary Islands and a few in South-East Asia*. One species, *P. americana* Mill., has been introduced into various tropical and sub-tropical parts and grown for its fruit, the Avocado.

P. americana Mill. syn. *P. gratissima* Gaertn. f.; *P. americana* var. *drymifolia* Blake THE AVOCADO, ALLIGATOR PEAR, BUTTER FRUIT

Bailey, 1949, 422; Ochse et al., I, 622, Fig. 108.

* The Asiatic species were previously referred to the genus *Machilus* Nees, but have recently been brought under *Persea* by Kostermans (*Reinwardtia*, 1961–62, 6, 189).

A large tree, 15–18 m. high, native of Central America, introduced into India and grown for its fruit in Bangalore, Nandi hills, Courtallam, Nagercoil, Shevaroys, lower Palnis and the foothills of the Nilgiris; it has also been grown in Poona. Leaves oblong or elliptic-lanceolate, up to 40 cm. long; flowers small, greenish, in compact panicles; fruit baccate, large, 5–20 cm. long, pear shaped, ovate or spherical, yellow-green to maroon and purple; skin thin or woody; pulp when ripe, has the consistency of firm butter, creamy to bright yellow in colour, of a delicious nutty flavour; seed single, large, globose or pointed (Naik, 408; Sriram, *S. Indian Hort.*, 1959, 7, 59).

There are three races of avocado grown: (1) the West Indian, (2) the Guatemalan, and (3) the Mexican, distinguished on the basis of the size and nature of the fruit, oil content of the pulp and anise-like odour present in their bodies. All the superior cultivated types of both the West Indian and Guatemalan races are considered to be of *P. americana* Mill., while the small fruited Mexican types are assigned to *P. americana* var. *drymifolia* Blake. Besides these, a large number of types, possibly inter-racial hybrids, are known showing characters intermediate between any two or three of the races. It has been suggested that possibly all the forms which now



FIG. 139—PERSEA AMERICANA—FRUITING BRANCH

comprise the edible avocado may represent only a single species (Schroeder, *Indian J. Hort.*, 1958, 15, 116; Ochse et al., I, 624-28; Ruehle, *Bull. Fla. agric. Exp. Sta.*, No. 602, 1958).

A large number of types are grown in India. Eight types are reported to be grown in Kallar and Burliar gardens in Madras and about 14 types in Bangalore. Characteristics of some of the types are given in Table 1.

Cultivation—Excepting for some arid tracts, the avocado can be grown in the tropical and sub-tropical parts of India wherever the rainfall ranges from 75 cm. to 180 cm. during monsoon. The avocado does not tolerate low temperatures, high summer temperatures, low humidity during the blossoming and fruit-setting period and violent winds. It generally favours cool and moist situations, well protected from high cyclonic winds, severe frosts or prolonged dry spells. The Mexican types are reported to be more resistant to cold than the West Indian or Guatemalan types. A maximum temperature, not higher than 40° and a minimum not lower than 5°, during the winter is said to be favourable [Gandhi, *Indian Hort.*, 1956-57, 1(2), 17; Rangacharlu, *Indian Fmg. N.S.*, 1951-52, 1(4), 11].

In parts of S. India favoured by the two monsoons, the avocado may be grown as a rainfed crop; but in parts where rainfall is restricted from June to September, the avocado needs irrigation during winter as well as summer months. The ideal soil for avocado is a loam of medium texture overlying a porous sub-soil. Heavy clay soils which get waterlogged during rains are not suitable.

For raising seedlings, the seed should be selected from fully mature fruits of healthy vigorous trees and planted as soon as possible after removal from the fruits. Seedlings raised in pots are transplanted in the orchards when they are 20-30 cm. high. Although seedlings grow rapidly and vigorously, the fruits produced by them are not exactly of the same quality and shape as of the parent trees. Consequently, it is preferable to adopt vegetative propagation, using the seedlings as rootstocks for budding or grafting. Shield budding has been recommended in some parts. Trials at Kallar and Burliar show that layering gives about 75% success when performed in January. Inarching on seedling rootstocks also gives 56% success when done in September (Gandhi, loc. cit.; Rangacharlu, loc. cit.; Naik, 409).

Avocado is usually planted in pits, 36 cm. x 36 cm. x 36 cm., the distance between trees varying from 8 to 10 m. depending upon their vigour. The young trees need support by staking against damage by winds. No pruning is needed for at least 7-10 years after planting, except removal of some of the basal branches, when they get shaded by the upper ones. Avocado needs irrigation at intervals of 6-10 days according to the availability of moisture in the soil and the intensity of heat. Manuring of 10 year old trees with 45 kg. of farmyard manure, 4.5 kg. of castor cake and 0.9 kg. of superphosphate two months prior to flowering has given good results.

The avocado comes into bearing about 5 years after planting and continues to fruit for about 25 years. The trees flower in March-April at Kallar and Burliar and occasionally produce a second blossom in

TABLE 1—CHARACTERISTICS OF AVOCADO TYPES GROWN IN KALLAR AND BURLIAR (NILGIRIS)*

Type	Season of maturing	Fruit shape	Fruit size (cm.)	Weight (g.)	Nature of pulp
Long	July-August	Pyriform & curved	18 x 8	382	Soft, buttery, sweetish
Round	July-August	Round	9 x 7.5	126	Cream-coloured, buttery
Fuerte	June-August	Pyriform	13 x 8.5	364	Cream-yellow, soft & buttery, with pleasant flavour
Pollock	July-September	Obovate	13 x 10	420-560	Greenish yellow, soft & buttery, with pleasant flavour
Peradeniya purple hybrid	July-October	Roundish	11 x 10.5	336-448	Creamy-yellow pulp, with a delicious flavour
Shenbaganur selection	April-June	Pyriform tapering towards the base from the middle	8.3 x 7	196	..
Trapp	June-September	..	12 x 9	448-504	..

* Sriram, *S. Indian Hort.*, 1959, 7, 59.

November–December ; the fruits ripen in August–September and May–June respectively. The long fruited type matures usually a fortnight earlier than the round fruited type. The fruits vary in weight from about 85 g. to as much as 1,000 g. and above. The avocado fruits do not soften on the tree. A slight change of rind colour to dull yellow in the round fruits and to a darker shade in the long ones is a good indication of the maturity for harvesting. The fruits may be harvested with the aid of a clipper [Naik, 410–11 ; Gandhi, *Indian Hort.*, 1956–57, 1(1), 11 ; 1956–57, 1(2), 17 ; Neal, 314].

The yields vary from 100 to 120 fruits for each tree in S. India. In America and elsewhere, an average tree produces about 45–67.5 kg. of fruits per season ; some trees yield as many as 1,200 fruits (Rangacharlu, loc. cit. ; Neal, 314 ; Barrett, 145).

Avocado fruits take about 4–5 days to soften after which they do not keep well. Hence they are generally eaten fresh. It is reported that the fruits can be stored for a short period at 4.5–5.0° (Kulkarni, *Poona agric. Coll. Mag.*, 1955–56, 46, 355).

Composition & Utilization—The ripe avocado fruit consists of the hard peel, the pulp with a butter-like consistency and a peculiar nutty flavour, and the seed. Fruits from Kerala contained on the average, 10.6% peel, 69% pulp, and 20.5% seeds. The fruit is eaten as salad flavoured with pepper, salt or sugar. It is also used in ice-cream. As compared to most other fruits, avocado fruit is highly nutritious being rich in fat and containing appreciable amounts of protein, minerals and vitamins. Analysis of the fruits from Nilgiris gave the following values: moisture, 73.6 ; protein, 1.7 ; fat, 22.8 ; carbohydrates, 0.8 ; and mineral matter, 1.1% : calcium, 10 ; phosphorus, 80 ; iron, 0.7 ; and ascorbic acid, 13 mg./100 g. Vitamin values of fresh avocado fruits are reported as follows: vitamin A (as carotene), 60–70 ; thiamine, 100 ; riboflavin, 170 ; ascorbic acid, 8,000 ; vitamin D, 10 ; biotin, 10 ; nicotinamide, 1 ; tocopherol, 3 ; and vitamin K, 8 µg./100 g. Pantothenic acid (850 µg./100 g.), folic acid (34 µg./100 g.) and pyridoxine (610 µg./100 g.) are also present. The fruits contain d-mannoketoheptose, tartaric acid (0.02%) and some tannin [Brown, 1941, I, 588 ; Nair & Punnoose, *Bull. cent. Res. Inst. Univ. Travancore*, 1951, 2A, 17 ; *Hlth Bull.*, No. 23, 1956, 48 ; Schwob, *Perfum. essent. Oil Rec.*, 1955, 46, 412 ; Hall *et al.*, *Calif. Agric.*, 1956, 10(11), 13 ; Jacobs, II, 1539, 1542].

The pulp has an exceptionally high content of fatty oil (66–84% on dry basis), which resembles other fruit-

coat fats in composition. A small quantity of avocado oil is produced from culls or damaged fruits in California and some central American countries. It is obtained by pressing the dehydrated pulp or by macerating the undried pulp with water and centrifuging the resulting slurry ; it can also be obtained by solvent extraction with petroleum ether. The oil has a heavy consistency, a weak odour and a taste reminiscent of hazelnuts. Avocado oil commands high price and is valued for use in cosmetic preparations and as a high grade salad oil. It is also used in superior quality soaps and in pharmaceuticals. The meal left after the extraction of oil from the pulp can be used as an animal feed or as manure. The yield and chemical composition of the oil varies widely. The oil obtained by solvent extraction of the fruit pulp (from Kerala) was green coloured and had the following characteristics: sp. gr.^{20°}, 0.9082 ; n_{D}^{20} , 1.4656 ; acid val., 2.41 ; sap. val., 184.9 ; iod. val. (Hanus), 85.5 ; acet. val., 22.5 ; R.M. val., 4.9 ; Polenske val., 0.7 ; and unsapon. matter, 1.9%. The fatty acids consisted of 26.9% saturated (palmitic and stearic, the former predominating) and 71.6% unsaturated acids (oleic and some linoleic). The oil contains lecithin and vitamins A, D and E (Nair & Punnoose, loc. cit. ; Eckey, 419 ; Jamieson, 35–36 ; Hoppe, 653).

The leaves contain 0.5% of a greenish yellow essential oil ($[a]_D$, +2.36°) which resembles tarragon oil (from *Artemisia dracunculus* Linn.) in odour and taste. Methyl chavicol is the chief constituent of the oil ; *d*-*a*-pinene and a paraffin (m.p. 53–54°) have been identified. The leaves are reported to contain pharmacologically active alkaloids. Aqueous extract of the leaves is said to have a fairly prolonged hypertensive action. Leaf juice showed bacteriostatic action against *Micrococcus pyogenes* var. *aureus*, *Escherichia coli* and *Bacillus subtilis*. Ingestion of the leaves proved fatal to rabbits [Gildemeister & Hoffmann, V, 102 : Henry, 781 ; *Rep. trop. Prod. Inst., Lond.*, 1959, 25 : Scharpenseel *et al.*, *Araneta J. Agric.*, 1956, 3(2), 46 ; *Chem. Abstr.*, 1945, 39, 2138].

Extracts of the dried peel and the seeds had antibiotic activity against *Micrococcus pyogenes* and *Sarcina lutea*. Ether extract of the dried seeds showed positive reaction for alkaloids. A process has been patented for the extraction of an antibiotic from the roots for use as a food preservative. The bark yields 3.5% of an essential oil ($[a]_D$, +0.77°) which has an anise-like odour and contains methyl chavicol as the main constituent with small amount of anethole

PERSEA

(*Chem. Abstr.*, 1956, **50**, 3629; 1954, **48**, 12872, 13958; 1951, **45**, 7723; Gildemeister & Hoffmann, V, 101).

The heartwood is pinkish to light reddish brown, not sharply demarcated from the thick, cream-coloured or pale brownish sapwood; it is light in weight (560-640 kg./cu. m.), of medium to coarse texture, very easy to work, but not very durable. The timber is not commercially important (Record & Hess, 213-14).

Persian Lilac — see *Melia*

Persian Manna Plant — see *Alhagi*

Persimmon — see *Diospyros*

Perthite — see *Felspar*

Peru Balsam Tree — see *Myroxylon*

Peruvian Bark — see *Cinchona*

Petalite — see *Lithium Minerals*

Petitgrain Oil — see *Citrus*

PETIVERIA Linn. (*Phytolaccaceae*)

Fl. Malesiana, Ser. I, **4**(3), 230.

A very small genus of herbs or sub-shrubs native of the warmer regions of America. One species *P. alliacea* Linn. has been introduced into India and grown in gardens. It is an erect herb, 30-90 cm. high, with elliptic-oblong or slightly obovate leaves and rose or white flowers in axillary and terminal racemes.

The plant smells of garlic. It imparts an unpleasant smell and taste to milk and meat of cattle fed on it. In tropical America, it is used as an insecticide and a remedy for whooping cough. It is also used as counter-irritant, in dentalgia, etc. Roots of the plant are considered diuretic, expectorant, anti-spasmodic, sudorific, vermisuge, abortifacient and emmenagogue, and used for nervous diseases. The seeds of the plant contain volatile isothiocyanates (Dalziel, 33; Hocking, 167; Uphof, 273: *Chem. Abstr.*, 1955, **49**, 5303).

PETROLEUM AND NATURAL GAS

Petroleum, often termed crude oil, mineral oil or natural oil, is a dark coloured viscous liquid principally composed of heavier hydrocarbons. After coal, it is the second major source of industrial energy. It frequently occurs with natural gas and is extracted from underground deposits in several parts of the world, viz. in North and South America, Western

and Eastern Europe, Africa, and Middle and Far East Asia. On refining, petroleum yields a number of fuel oils, lubricants, solvents, waxes and asphaltic bitumen.

The world reserves of crude oil in 1960 were estimated at 30,500 million tonnes, of which c. 63% occurred in the Middle East countries. Indian reserves have been estimated to be of the order of 100 million tonnes. The world output in 1963 was 1,304.55 million tonnes; of this total, the production in U.S.A. was 28.6%, Middle East countries 26.4%, U.S.S.R. 15.7%, and India 0.1% (Table 1). The production of oil in India dates back to 1890, when oil was discovered in Digboi (Assam) and a miniature refinery was set up at Margherita.

Petroleum crudes vary greatly in composition and physical properties (*n*, 1.39-1.49; [a]_n, 0° to 1.2°; sp. gr., 0.82-0.96; b.p., less than atmospheric temperature to over 300°; f.p., 15.5° to -45.5°; sp. heat, 0.40-0.52; cal. val., 18,000-19,000 B.t.u.). They range in colour from black, through red, brown and green to a light yellow shade. They consist mainly of hydrocarbons (H, 11-13%; C, 84-87%); but varying

TABLE 1—WORLD CRUDE OIL PRODUCTION*

(million tonnes)

Country	1961	1962	1963
Algeria	15.64	20.49	23.70
Argentina	12.15	14.05	13.80
Canada	29.73	32.86	35.85
Indonesia	21.45	22.80	22.80
Iran	58.70	65.41	73.00
Iraq	49.03	49.19	55.50
Kuwait	82.48	92.18	97.50
Kuwait Neutral Zone	9.80	13.04	16.40
Libya	0.70	8.42	21.00
Mexico	15.21	15.92	16.50
Rumania	11.58	11.86	12.00
Saudi Arabia	69.23	75.75	81.00
U.S.A.	353.43	360.77	373.50
U.S.S.R.	166.07	186.00	205.00
Venezuela	152.15	167.31	169.65
Others	72.03	78.31	87.35
TOTAL	1,119.38	1,214.36	1,304.55

* *Oil Statist.*, 1964, **2**(1), 3-4.
Indian production for 1961, 1962 and 1963 was 0.44, 1.05 and 1.30 million tonnes respectively.

amounts of oxygen, nitrogen and sulphur-bearing compounds are invariably present. As many as 18 different series of hydrocarbons have been identified in various crudes ; these include : paraffins, $C_{11-14}H_{22}$; olefines (polymethylenes), $C_2H_4-C_{30}H_{60}$; acetylenes, $C_{12}H_{22}-C_2H_{16}$; turpene, $C_{23}H_{42}-C_{25}H_{46}$; and benzenes, $C_6H_6-C_{10}H_{14}$. Most crude oils have an unpleasant odour due chiefly to the presence of sulphuretted hydrogen and organic sulphur compounds, particularly mercaptans.

Petroleum crudes are broadly grouped under paraffin-base oils and asphalt-base oils. Paraffin oils yield at low temperatures, an appreciable proportion of light coloured wax, not readily soluble in acids or solvents dissolving solid hydrocarbons. Asphaltic oils are generally characterized by the predominance of polymethylene series of hydrocarbons, and on slow distillation leave a dark asphaltic residue, usually jet black, lustrous, and with a well developed conchoidal fracture. The residue is readily attacked by the stronger acids and dissolves in solvents like chloroform and carbon bisulphide (Uren, 3-5).

Natural gas consists of a mixture of lower paraffin hydrocarbons, mainly methane (80-90%) with smaller amounts of ethane, propane, butanes and pentanes. The proportion of hydrocarbons varies considerably in the different production areas. Minor but varying quantities of carbon dioxide, nitrogen, hydrogen sulphide and occasionally helium are present in the natural gas ; in some cases the nitrogen content is so high that it renders the gas incombustible. Gases containing hydrogen sulphide and organic sulphur compounds are known as Sour gases. Some gases contain high percentage of carbon dioxide and are a source of Dry Ice. In addition to being an important source of domestic and industrial fuel, carbon black, natural gasoline, liquefied petroleum gas, helium and dry ice, natural gas offers paraffinic hydrocarbons, which can be processed into a large number of synthetic products, known as petrochemicals (Encyclopaedia Britannica, XVI, 163-64; McGraw-Hill Encyclopedia of Science and Technology, IX, 6; Kirk & Othmer, VII, 61).

ORIGIN OF OIL AND GAS

It is now universally believed that oil and natural gas are of organic origin, though it has also been suggested that petroleum may be an original cosmic substance like iron, silicates and methane. The source raw materials of oil are derived, among the plants from marine bacteria, algae and dinoflagel-

lates, and among the animals from foraminifers, radiolarians, crustaceans, molluscs, echinoderms and vertebrates. The deoxygenating action of anaerobic bacteria on the plant and animal remains and the processes of polymerization and methylation have resulted in the production of hydrocarbons, which over a period of time, during migration, slowly changed in their composition, and gave rise to complexities and differences met with in various petroleum crudes. The process of oil formation, begun about 400 million years ago, occurs in strata ranging from Cambrian to the Recent ; the periods of greatest productivity are the Tertiary, Cretaceous, Carboniferous and Ordovician.

Inundated globules of oil, floating in subsurface water accumulate in the upper horizons of the porous strata, covered by an impervious rock and occupy an intermediate zone between the gas and the underlying water. The phenomenon of translation and separation of gas, oil and water is influenced by the dip of the formation, rock permeability, gas pressure and gravity, and the viscosity of oil. Reservoir rocks are usually sandstones, semiconsolidated sands, conglomerates, or limestones. Their lithologic properties important in determining storage capacity, resistance to flow, and rate at which fluids may enter the wells are, the size and shape of the pore spaces, their continuity, and the percentage of the total volume of the rock they represent.

Oil filtering through certain types of clay and earth, particularly Fuller's earth, is subjected to a certain degree of fractionation and is partially decolorized. Light coloured, transparent mobile oils of low specific gravity are thus derived from comparatively heavy, viscous and dark material.

The migrating oil, when arrested in a trap of geological formation, results in an accumulation of oil. Traps favourable to petroleum and gas accumulation include, anticlines, domes, monoclines and terraces, faults and unconformities, lenses of porous rocks in association with carbonaceous shales, salt domes and volcanic necks ; they are met with in oil fields in an endless variety of combinations (Bateman, 657-59; Uren, 8-9, 12-16, 27-28; Levorsen, 475; ONGC News Lett., 1958-59, 2, 119; Hunter, L., 14-16; Petrol. Handb., Lond., 62, 44).

EXPLORATION AND DISTRIBUTION

The work for extensive exploration of oil in India using modern techniques of magnetic, gravity and seismic surveys and the study of electro-

PETROLEUM AND NATURAL GAS

logs prepared for borings, was commenced only in 1948, when the Geological Survey of India expanded its programme and started reconnaissance and detailed geophysical mapping of the Punjab, Himachal Pradesh, Assam, Kutch, and Andaman & Nicobar Islands. The Burmah Oil Co. also intensified its activities in the vicinity of Nahorkatiya. The Indo-Stanvac Project was set up as a joint venture, between the Government of India and the Standard Vacuum Oil Co. in December 1953, for the exploration of oil in the West Bengal basin. The Oil and Natural Gas Directorate established in 1955 for the development of the mineral oil resources of India, was expanded into a Commission in 1956. Soviet and Rumanian collaboration was secured in the efforts to develop oil and natural gas exploration in India and a scheme for the training of Indian technicians in oil prospecting was launched. In November 1959, the revised Petroleum and Natural Gas rules were formulated, to facilitate inviting foreign companies to join the quest of petroleum in India.

In India the possible oil bearing sedimentary basins are found to cover an area of about one million sq. km. (400,000 sq. miles) fringing the Gondwana massif of crystalline rocks. The distribution of these basins is given in Table 2. They contain marine and freshwater deposits and range from Jurassic to Recent. These basins consist of: (1) the lithified and elevated sediments forming the fold mountains and hill systems as a result of orogenic movement, and inclu-

ding Tertiary hills and ranges of Assam, Manipur and Tripura, the foot hills of Himalayan ranges from Assam to Jammu and beyond, and Jurassic basin occupying the central portion of Kutch; (2) sediments exposed by erosion following gentle uplift movements in structural and depositional coastal depressions, filled from time to time as a result of marine transgression; they include the marine sediments in the Coromandel coast (belonging to the Cretaceous and Tertiary), in Godavari-Krishna basins (Jurassic), in Kerala (Miocene), and in Jaisalmer and coastal areas of the Kutch (Jurassic, Cretaceous and Tertiary); and (3) the lithified sediments concealed under thick mantles of alluvium and/or desert sands, folded or otherwise, and covering the entire Indo-Ganga-Brahmaputra alluvial basin stretching from one end of northern India in East Punjab to the other end in Assam and a large part of Rajasthan desert, with portions of Jaisalmer.

Andaman and Nicobar Islands—A complete stratigraphic succession of marine geosynclinal sediments, ranging from Cretaceous to Pliocene, crops out in these Islands. Mud volcanoes are present in one of the Islands and traces of paraffinous crude oil have been reported in the mud.

Assam—During the construction of the first railway line in north eastern Assam hill ranges from Dibrugarh to Margherita, several oilshows were noticed near Digboi, where the very first well, drilled in 1889 struck oil; further drilling confirmed possibilities of a deposit, which later developed as the first commercial oil field of India. As a result of intensive geological effort followed by systematic exploration and developmental drilling, the Digboi field was producing over 5,600 barrels per day during 1944. Though several test wells have been drilled in the exposed areas of Upper Assam, none of these showed promise of development as a commercial field.

The vast alluvial area of the Brahmaputra and its tributaries, which did not attract much attention in early days of oil exploration, showed the existence of anticlinal 'highs' near Nahorkatiya, beneath the alluvial blanket, during a torsion balance survey in 1925–26. The depth of possible oil bearing horizons was estimated to be of the order of 3,000 m. and more. The first test well drilled in Nahorkatiya in 1952–53, to a depth of 3,550 m. was a good producer. This structure delineated by seismic surveys extends over 30 sq. km. within the known oil bearing basin of Brahmaputra valley and is considered prospective for oil and gas exploration.

TABLE 2—DISTRIBUTION OF POSSIBLE OIL BEARING SEDIMENTARY BASINS IN INDIA*

Location	Area sq. km.
Assam, Tripura & Manipur	77,700
West Bengal including parts of coastal Orissa & Sundarbans	77,700
East Punjab including Himachal Pradesh and Jammu & Kashmir	129,500
Rajasthan	120,400
Cambay-Kutch	177,400
Ganga Valley	367,800
Madras coast	44,000
Andhra coast	24,600
Kerala coast	15,500
Andaman & Nicobar Islands	7,800

* Ghosh, Proc. Symp. Developm. Petrol. Resources of Asia and Far East, Bangkok, 1959, 131.

In the Surma valley region, Badarpur oil field was discovered in 1901. Sixtythree wells yielding mostly poor quality oil were drilled in the field, which stopped production in 1933. The several test wells drilled in the various anticlinal structures of the valley were unsuccessful, apart from some shows of oil and gas in Masimpur. In Tripura State, long anticlinal structures developed in upper Tertiary freshwater rocks have been recognized and gas seepages have been recorded in some places.

U.P., Bihar and North Bengal (Ganga Valley)— Ganga basin has an uneven basement topography between East Punjab and Bihar and is probably segmented into 4 or 5 sections roughly parallel to Himalayan range. At some places, the basement is reached within about 1,500 m. with intervening areas containing sediments probably 6,000-9,000 m. in thickness. Study wells have been drilled in Budaul (Ujhani) and Kasganj areas.

In Bengal basin, the older sediments under the thick alluvium rest on basic lava flows, presumably of late Jurassic age. Deep test wells have revealed the presence of marine, estuarine, brackish and continental type of sandstones, shales and fossiliferous limestones, some of which are characterized by the presence of Nummulites and Assilina.

Gujarat— Gas seepage near Jagatia in Kathiawar was first reported in 1921 and a shallow well dug for water yielded gas at 2,800 cu.m. per day, declining to half the quantity after a couple of months. Seepages of natural gas are present over a wide area on both sides of the gulf of Cambay. Drilling has revealed several oil bearing horizons in a thick succession of marine sediments, which rest on a basement faulted down to a depth of more than 3,000 m.

Other regions. The Himalayan foot hills between Jammu and Assam consist of folded and faulted deposits generally known as Siwaliks. Natural gas occurs at Jawalamukhi in the Kangra district and at some places in Jammu. The well drilled at Jawalamukhi revealed the presence of gas at 890-950 m. below the surface.

The basement in the Punjab plains has been found to be fairly uneven and generally within 1,500-3,000 m. from the surface. Two wells have been drilled at Adampur and Januari in the Hoshiarpur district. Over large areas in Jaisalmer, marine Jurassic rocks of shallow water coastal facies are exposed and some of the beds contain mainly marine fossils similar to those found in Kutch. The basement is at shallow

depth in the eastern part and reaches a depth of 6,000 to 9,000 m. in northern and western areas.

The Jurassic and Cretaceous sediments in Godavari-Krishna basin are locally marine in the exposed region and are likely to be deep water facies further down dip. In the Cauvery basin, the presence of more than 3,000 m. of exposed thickness of marine Tertiary sequence in the southern part makes the prospects of finding oil good. In Kerala, the thickness of the basin sediments, as indicated by the gravity magnetic work, is not considerable on land. The offshore area may offer better prospects in the region (Ghosh & Rao, *Proc. Symp. Developm. Petrol. Resources of Asia and Far East*, Bangkok, 1959, 138 ; Ghosh, *ibid.*, 131 ; Metre, *Proc. Indian Sci. Congr.*, 1961, pt II, 112 ; *Annu. Rep., Oil nat. Gas Comm.*, 1962-63, 4-27 ; *Indian Petrol. Handb.*, 97).

PETROLEUM

PRODUCTION

The three agencies working for the production of crude petroleum and development of oil fields in India are the Assam Oil Co. which operates the Digboi deposits ; the Oil India Ltd., which is a 50:50 partnership between the Government of India and Burmah Oil Co., and works for the exploitation of Nahorkatiya and Moran resources ; and the Oil & Natural Gas Commission which manages the production and developmental activities of the Gujarat and Rudrasagar oil fields.

The methods employed for drilling use (i) cable tool system and (ii) rotary system. Cable tools are usually used for wells less than 600 m. in depth, but have also been employed at depths of 3,000 m. to break through cap rocks reached by rotary drilling. In most formations, rotary rig drills 30-90 m. per day as compared to the 6-45 m. by cable tools and is more economical for drilling deep holes : 90% of today's drilled footage is made by rotary machinery. Both systems require a derrick to support the drilling equipment ; both pulverize the rock, the cable tool by a pounding action and the rotary tool by cutting or grinding.

Of the 998 wells drilled in Digboi field up to December 1959, only about 300 have yielded the minimum total production for a profitable well in this field. The Digboi crude has API (American Petroleum Institute) gravity, 37.73° ; pour point, 32.2° ; and recoverable wax content, 16% ; it is of the mixed paraffin and asphalt base type and contains a fair proportion of cyclic hydrocarbons.

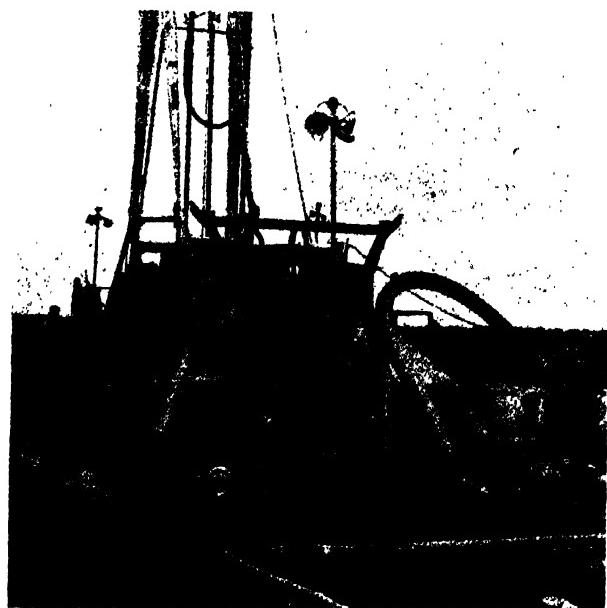


FIG. 140—PETROLEUM DRILLING EQUIPMENT (LOWER PORTION)

The oil from these fields is transported by pipe line to Nunmati and Barauni refineries. The crude from Naharkatiya is similar to the one obtained at Digboi with a slightly higher proportion of cyclic hydrocarbons. The Moran crude has API gravity, 27-34°; pour point, 27-32°; and recoverable wax content (for one well), 8% [Metre, loc. cit.; *ONGC Rep.*, 1962-63, 1(2 & 3), 36; *Annu. Rep., Oil nat. Gas Comm.*, 1962-63, 1; Indian Petrol. Handb., 92-99].

REFINING

Petroleum refining consists in fractional distillation of the crude with a view to separate it into different fractions, followed by suitable treatment of these fractions to finish them into desirable products. The processes used are basically simple but the plants are complex and their operation requires a highly specialized knowledge.

A refinery with half a dozen processes, including distillation and cracking, can produce gasolines, kerosene and fuel oils. The manufacture of solvents requires two or three more processes; lubricating oil production, the addition of at least five more; waxes, another two or more. Asphalts, greases, coke, gear oils, liquefied petroleum gases, alkylate and all other kinds of products that can be made would require fifty different processes. Some of the most extensive

refineries produce over six hundred different products from petroleum crudes.

Some crudes do not have hydrocarbons suitable for all the needed products; and a crude composed of suitable hydrocarbons cannot produce all the needed fractions through a particular operation. Different crudes may, therefore, be required to obtain different products, and a crude may be subjected to different operations to manufacture products having overlapping boiling ranges. Fractions into which crude petroleum is generally separated are given in Table 3. The kerosene, stove oil and light gas oil fractions together are referred to as 'middle distillates'. Fractions up to heavy gas oil are separated by distillation at atmospheric pressure; this leaves behind the reduced crude. Distillation under vacuum is necessary to separate the vacuum gas oils from the pitch. If the reduced crude is of suitable composition, the vacuum gas oils are separated into three lubricating oil fractions and a heavy gas oil. For details, refer to *Wtth India—Industrial Products*, pt VI, 234-42.

Fractionation—Fractionation is carried out in a tower, divided into a number of horizontal sections

TABLE 3—COMMON FRACTIONS FROM CRUDE PETROLEUM*

Fraction	Boiling range	Uses
Fuel gas	- 162° to + 42°	Methane; ethane, some propane; used as refinery fuel
Propane	- 42°	Liquefied petroleum gas
Butane	- 12° to + 0.5°	Added to motor gasoline to increase volatility; liquefied petroleum gas
Light naphtha	- 1° to 150°	Added to motor gasoline; depentanized & added to heavy naphtha, as feed for reforming
Heavy naphtha	150°-205°	Catalytic reformer feed; blended with light gas oil to form jet fuels
Kerosene	205°-260°	Illuminant, fuel
Stove oil	205°-290°	Fuel
Light gas oil	205°-315°	Furnace & diesel fuel
Heavy gas oil	315°-430°	With vacuum gas oils as feed for catalytic cracking
Vacuum gas oils	430°-540°	Catalytic cracking feed; suitable crudes yield lubricating oils
Pitch	595° and above	Heavy fuel oil & asphalts

* Purdy, 127-28; Information from Ministry of Petroleum and Chemicals, Govt. India.

by metal trays or plates. Each tray is at a different temperature, the bottom one being the hottest because of the incoming heated feed and the top one the coolest because of the reflux, i.e. condensed and cooled vapours pumped into the top. The hydrocarbons with about the same boiling temperature tend to collect on the same tray. Thus, a sidestream product can be obtained by tapping the tray containing hydrocarbons with the desired boiling point. During fractionation, light naphtha and gases are taken as vapour from the top of the tower, reduced crude from the bottom of the tower, and heavy naphtha, kerosene and two gas oils as sidestream products. Reduced crude on further processing yields vacuum gas oil, raw lubricating oil distillates and asphalt.

Cracking The process of cracking is used mainly for the manufacture of high quality gasoline from heavy naphtha and gas oils. Thermal cracking involves pumping of the feedstock through a unit that heats it to the required temperature, holds it for the proper time under a suitable pressure, and then discharges the cracked material into distillation equipment. In the catalytic cracking, the oil and fluidized catalyst flow together into a reaction chamber where the cracking takes place. Cracking breaks up large hydrocarbon molecules into fragments of various sizes. The smallest fragments are hydrocarbon gases and the larger ones boil in the gasoline range; some of the fragments join together to form molecules larger than those of the oil being cracked, and form heavy oils, tar and coke.

Gasolines produced by cracking have a higher octane number than the straight-run gasolines obtained directly from crude petroleum. The heavier fractions, such as heavy gas oil formed during cracking, constitute an important source of more gasoline, through further cracking. The olefinic gases derived find use in the refinery as feed for polymerization plants, where high octane polymeric gasoline is made. In some refineries, the gases are used to make alkylate, a high octane component for aviation and motor gasolines. The cracked gases are the starting points for many petrochemicals.

The residual oil may contain lubricating oils and waxes in sufficient quantity or be rich in asphalt. It may be used for recovery of these materials, or vacuum-distilled to recover heavy gas oils for catalytic cracking feed, or utilized as a heavy grade fuel oil.

Treating—Fractions produced by crude distillation, cracking and reforming contain small amounts of

undesirable components which are removed by treatment with various substances like sodium plumbite, copper chloride, sulphuric acid, clay, bauxite, or lye alone or with the addition of certain chemicals. New processes called hydrotreating, which use hydrogen, are being increasingly employed. The most common impurities are sulphur compounds, besides smaller amounts of acidic and nitrogenous compounds. Sometimes olefins must be eliminated from a feedstock or aromatics removed from a solvent. Similarly, polymerized material, asphaltic material or resins may be impurities, depending on whether or not their presence in a finished product is harmful (Purdy, 125-28, 138-49, 154-71, 203-10).

Refineries—Digboi refinery of the Assam Oil Co. was the only refinery operating in India till 1954. It was able to meet c. 7% of the country's requirements of petroleum products. In 1948, three of the oil distributing companies operating in India, viz. the Standard Vacuum Oil Co. (now Esso Standard), Burmah-Shell, and Caltex Co., signed agreements with the Government of India to set up refineries in the country. The first two companies established refineries at Trombay (near Bombay) and the last one at Vishakhapatnam (Andhra Pradesh). The three refineries went on stream in July 1954, January 1955, and April 1957 respectively. The annual throughput of these coastal refineries in 1963 were (in million tonnes): Burmah-Shell, 3.5; Esso, 2.4; and Caltex, 1.05. Burmah-shell refinery has since increased its throughput to 3.75 million tonnes, while Esso has raised it to 2.5 million tonnes.

The requirements of the crude for the three coastal refineries are obtained from Middle East countries and Indonesia. The Burmah-Shell refinery obtains crude oil from Kuwait, Iran and Qatar. Typical characteristics of oils from these areas are: API gravity, 32.0°, 35.0°, and 41.1°; paraffin wax content, 2, 7, and 2%; Reid vapour pressure (RVP), 3.4, 3.3 and 3.6 kg.; and pour point, -15°, -15°, and below 0°, respectively. The Esso refinery uses Aramco and Safaniya crude from the Middle East, which is a blend of crudes from several oil fields in Saudi Arabia. It is a sour, mixed-base type and has relatively low paraffin content (API gravity, 34.35°; and RVP, 1.4-2.3 kg.). The Caltex refinery uses both Middle East crude and Minas crude from Sumatra. The latter is a thick, waxy, blackish green, sweet smelling viscous oil; due to its excellent base qualities, it is used for the production of high grade products.

Following the discovery of oil in Nahorkatiya and

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contiguous areas, two refineries have recently been set up in the public sector at Nunmati (Assam) and at Barauni (Bihar). These refineries have crude capacities of 0.75 million tonnes and 2.0 million tonnes/year respectively. The oil obtained from the oil fields of Gujarat will be processed at the third public sector refinery (capacity, 3 million tonnes) at Koyali. The public sector refineries were operated by the Indian Refineries Ltd. which has been merged since September 1964 with the Indian Oil Co. Ltd., to form the Indian Oil Corporation Ltd.

PETROLEUM PRODUCTS

A great variety of products are obtained through refining of crude oil. The gases recovered are burnt as fuel in the refineries, and yield gas black which finds application in rubber tyres, inks and paints. A series of alcohols (including propyl, butyl, amyl and hexyl) are derived from these gases for use as solvents in lacquers, soaps and essential oils. The hydrocarbon gases are also liquefied for use as illuminant, fuel and in metal cutting : other products thus obtained include liquefied gasoline, petroleum ether, pentane, hexane, and solvents for drug extraction.

The distillates next recovered from the refining of crude oil are the naphthas, which yield motor gasoline, aviation gasoline, commercial solvents, benzine for dry cleaning, and fractions for gasoline blending and for use in paints and varnishes. The products derived from the middle distillates include kerosene, stove oil, tractor oil and signal oil for railroads and lighthouses. The gas oils are made into furnace oil, diesel fuel oil, and gasoline by cracking, and are used in the carburetion of water gas and as fuel for metallurgical purposes. The absorber oil enters into gasoline and benzol recovery.

The heavier distillates next derived yield a variety of technical heavy oils, waxes and lubricating oils. From the heavy oils are obtained: white oil used for lubricating special machinery and packing fruit and eggs ; medicinal oil both for external and internal uses and for making salves, creams and ointments ; ink oil ; saturating oil for wool and twine manufacture ; emulsifying oil ; electrical oil for transformer and switches ; and flotation oil for metal recovering. Waxes are widely used for making candles, candy, and chewing gum ; for preserving fruits and vegetables ; as laundry detergents ; and in etching. Saturating wax is applied to cardboards, matches, and paper. Lubricating oils find extensive application in machinery.

From the residues of distillation are obtained greases for gears, switches and cups. Petrolatum or petroleum jelly, separated from greases by refining, is utilized in emollients and for metal coating and lubrication. The residual oils are employed as industrial and bunker fuel oils and for making gasoline by cracking. Asphalt and pitches, the residual products of petroleum, are used for roofing, paving, briquetting, rubber making and plastic composition.

Among the host of other materials produced in the refining operation, coke is used for making electrodes and abrasives and also as fuel ; petroleum sulphonates for making oil soluble detergents ; mercaptans as gas odorants and as chemical intermediates ; hydrogen sulphide for recovering sulphur ; and heavy aromatic type oils as rubber plasticizers.

The major refined products in Indian refineries are motor gasoline, kerosene (superior and inferior grades), high speed diesel oil (H.S.D.), light diesel oil (L.D.O.) and fuel oil. Liquefied petroleum gas (L.P.G.) and asphaltic bitumen are produced by Burmah-Shell and Esso refineries. The Assam Oil refinery also manufactures bitumen, lubricating oils, paraffin waxes, petroleum coke and other minor products (van Nostrand, 1958, 1220 ; Purdy, 435-36 ; With India-Industrial Products, pt VI, 242-50, 253-59).

STORAGE AND MOVEMENT

Petroleum crude and products are generally stored in fixed roof or floating roof tanks, depending on the economic balance of vapour loss and initial cost of storage. Fixed cone roof tanks are used for low vapour pressure materials such as furnace oil, diesel oil and kerosene. The tanks consist of vertical welded or riveted steel with shallow conical roof supported by light internal bracing. The pressure variations inside the tank are regulated by valves located in the tank roof.

The floating roof tank is used for high vapour pressure stocks, such as crude oil, light naphthas and gasolines. The roof floats on the surface of the liquid and since the air space is limited, the tank almost completely eliminates the vapour loss. Floating roof tanks are also used where the contact of the product with air is undesirable as in the case of catalytic feedstocks. Products such as L.P.G. having high vapour pressure are stored in bullets (hemispherically ended cylinders) or spheres (spherical tanks) capable of withstanding internal pressure up to 14 kg./sq. cm.

For the storage of high flash point products such as fuel oil, the roof fittings comprise a number of dip

holes for measurement and venting. One or two man-holes are also provided. The vents are sized according to pumping rates and temperature. The roof fittings of tanks containing crude oil, gasoline and kerosene are more complicated. The dip holes are made tight and are supplemented by pressure and vacuum relief valves. The valves allow vapour to escape when the pressure reaches a predetermined limit (usually 6.3 cm. water gauge below atmospheric pressure) and also allow air to enter when pressure inside falls too far below the atmospheric pressure. The so-called breathing vapour losses are thereby reduced to minimum. Losses may be further curtailed by insulating the tank roof and painting it with a heat-reflecting paint, like aluminium paint.

Tanks are usually equipped with inlet, outlet, and drain pipe line connections and also with internal mixing jets or internal movable delivery pipes, called swing arms, for blending purposes. Tanks containing viscous or solid products, such as bitumen products are kept hot by steam-heating coils in the bottom of the tanks, and the tanks are insulated.

In refineries, the products are handled by a system of transfer pumps, pipe lines and intermediate and storage tanks. The final streams are transferred through separate pipe lines under pressure or by means of pumps to intermediate or final storage. For certain products such as bitumen, pipe lines are heated by steam tracing.

Finished fuel products are moved from refineries by pipe line to terminals from where further transfers are made by tank wagons and tank trucks. In case of coastal refineries, the products are moved by pipe line into tankers berthed at marine terminal. Bitumen and fluid cutbacks are delivered in steel drums, which are filled by gravity from overhead storage tanks and transported by mechanical conveyers and storage yards (Information from Burmah-Shell Refineries Ltd., Bombay, and Esso Standard Refining Co. of India Ltd., Bombay).

MARKETING

Petroleum distribution in the country till recently was carried out by the following companies: (1) Esso Standard Eastern Inc. (formerly Standard Vacuum Oil Co.) ; (2) Burmah-Shell Oil Storage & Distributing Co. of India Ltd. ; (3) the Caltex (India) Ltd. ; (4) the Indo-Burmah Petroleum Ltd. (I.B.P.) ; (5) Western India Oil Distributing Co. Ltd. ; and (6) Burmah Oil Co. (Indian Trading) Ltd. [B.O.C (I.T.) Ltd.]. In June 1959, the Government of India set up at Bombay a

distributing company under the name of the Indian Oil Co., now merged with Indian Refineries Ltd. and called the Indian Oil Corporation Ltd. The company constructed installation at the ports, and depots at many upcountry points, and started distributing the products of the first public sector refinery and products imported from rupee payment sources.

The Assam Oil Co. markets its products outside Assam through the Burmah-Shell Storage and Distribution Co. by virtue of an arrangement with the B.O.C. (I.T.) Ltd. The B.O.C. (I.T.) Ltd. has a sales agreement also with I.B.P. sharing the market for the refined products in Cachar area of Assam. Under arrangements with Esso and Caltex, the B.O.C. (I.T.) Ltd. supplies a fixed quantity of motor spirit and kerosene for sale by the latter in Assam. The I.B.P. draws supplies from B.O.C. (I.T.) Ltd. as well as from Burmah-Shell installations and depots. The Western India Oil Distribution Co. Ltd., an Indian marketing organization, has entered into an agreement with Compagnie Francaise Des Petrols, obtaining supplies of kerosene and high speed diesel oil from Iranian Oil Refining Co., Abadan.

All the companies have a number of main installations which receive oil in bulk by pipeline, tankers or tank wagons : they provide storage, and also pack oil for distribution in tins. The major installations are situated at Bombay and Vishakhapatnam, where the three refineries are located. Installations for imported oil products are located at Calcutta, Madras, Cochin, Okha, and Kandla. The B.O.C. (I.T.) Ltd. draws refined products from the Assam Oil Co. installations at Tinsukia and Digboi.

All petroleum products leaving the main installations are carried by rail, road tank cars, lorries, bullock carts, and boats to distribution centres. The best known package is the 18 litre (4 gal.) kerosene tin. Barrels of various sizes are also used ; a barrel of standard size holds 205 litres (45 gal.). Dangerous oils, such as aviation and motor spirits, are carried in specially made heavy barrels.

Small installations or depots are located in all cities and towns. They receive oil from main installations and distribute it locally. Distributing companies also have a large number of accredited agents/dealers, who undertake retailing over considerable areas.

Aviation spirit and aviation turbine fuel are retailed in bulk in various airports. Motor spirit is generally sold through kerbside pumps, though some quantities are also sold in barrels and in one litre tins. High speed diesel oil, power kerosene, and lubricants are

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also retailed by pumps at service stations. Kerosene, which has more consumers than any other petroleum product, is normally sold in tins and large quantities are retailed (in pint bottles) by dealers. Diesel fuels and fuel oils are delivered in bulk or in barrels, usually direct from an installation to the factories. The number of installations commissioned or under construction by the different oil distributing companies as in February 1962, was as follows: main installations, 37; depots, 1,134; retail pump outlets, 6,178; and airfield outlets, 56.

Where oil traffic in density moves over considerable distances, before it starts thinning into various sections, pipeline transportation is a possible means of bulk movement. The Government of India has been considering the possibility of laying pipelines from the refineries to the consuming centres in West Bengal and Uttar Pradesh.

The Indian Oil Corporation Ltd. (Marketing Division) will be setting up four bottling plants for liquefied petroleum gas at Barauni, Kanpur, Calcutta, and Delhi. L.P.G. will be carried to bottling centres by tank wagons from the Barauni refinery (With India-Industrial Products, pt VI, 260-63).

TRADE

The production of crude in the country has almost trebled from 0.44 million tonnes in 1961 to 1.30 million tonnes in 1963. The total output of the petroleum products in the refineries during 1961, 1962 and 1963 were 6.09, 6.584, and 7.745 million tonnes respectively. The consumption of petroleum products has increased from 2.26 million tonnes in 1948 to 9.55 million tonnes in 1963. The requirements of petroleum products have been estimated at 12 million tonnes in 1965, and 20 million tonnes in 1970. [Oil Statist., 1964, 2(1), 4; World Petrol., 1960, 31(10), 45; Metre, loc. cit.].

Demand of petroleum products in India shows, that kerosene may continue to be in deficit for a number of years, while gasolines may continue to be surplus. Technological and fiscal measures are being adopted to minimize the consumption imbalance.

In March 1959, the Government of India increased the duty on diesel fuel to arrest its consumption. Specifications of high speed diesel fuel were amended and the minimum value for flash point was lowered from 65° to 55° , making it possible for a part of the naphtha which was included in motor spirit to be diverted to H.S.D. Oil.

Imports.—Prior to the setting up of the three

coastal refineries, the bulk of petroleum products was imported. The imports are now limited mainly to the difference between the growing demand and indigenous production. Imports of crude for the years 1960, 1961, and 1962-63 were valued at Rs. 405.7, 393.1 and 301.5 millions respectively. The total value of imports of petroleum products in recent years is given in Table 4 [Oil Statist., 1962, 1(2), 6-11].

Prices.—The basic selling prices of all major petroleum products, except bitumen and lubricants, were governed until May 1958 by the Valued Stock Account agreement with Burmah-Shell based on f.o.b. Ras Tanura posting, plus other elements. Other oil companies followed the Burmah-Shell prices. In May 1958, the Government accepted and mopped up *ad hoc* price reduction offered by Burmah-Shell. Agreements were reached on a new price formula for bulk refined products and bitumen. Table 5 gives the tax-free prices and Table 6 excise/customs duty rates on various petroleum products on 1.1.1964.

In 1959, total turnover of marketing companies amounted to Rs. 2,894 millions; 2,064 million gal. of products were sold. The total capital invested by the companies was Rs. 800 millions, of which the fixed assets amounted to Rs. 266 millions (Indian Petrol. Handb., 68).

NATURAL GAS

The proved gas reserves in the country amount to c. 32,000 million cu. m. in Assam and c. 11,000 million cu.m. in Gujarat.

Natural gas is transported through pipe lines (diam., 51-56 cm.) at pressures varying between 14 and 28 kg./sq.cm., though higher pressures are also used; where natural well pressures are inadequate, compressing stations are installed. In colder climates, during winter it may become necessary to install dehydrating plants on large lines to eliminate choking of lines due to the formation of crystalline hydrates of methane, ethane, propane and isobutane. The hydrates of these hydrocarbon gases are stable at all temperatures below 19° .

TABLE 4—VALUE OF IMPORTS OF PETROLEUM PRODUCTS*
(million Rs.)

1959	422.3
1960-61	428.0
1961-62	472.5
1962-63	547.0

* Information from Ministry of Petroleum and Chemicals, Govt. India.

TABLE 5—BASIC CEILING SELLING PRICES (TAX-FREE) FOR VARIOUS PETROLEUM PRODUCTS (1.1.1964)*

Products	Unit	Kandla Rs.	Bombay Rs.	Madras Rs.	Calcutta Rs.
Aviation spirit 100/130	Kilolitre	236.30	240.70	251.73	263.77
Aviation spirit 115/145	"	..	260.53	271.56	283.59
Aviation spirit 73 O.N.	"	..	218.72	..	237.76
Aviation turbine fuel	"	129.14	129.14	142.38	144.53
Motor spirit					
Ex-port local pumps (within Free Delivery Zone)	Tonne	205.52	205.52	212.14	221.98
Ex-upcountry pumps (within Free Delivery Zone)	"	219.27	219.27	225.89	235.73
High speed diesel oil	Kilolitre	138.43	138.43	150.26	149.42
Kerosene superior	"	158.84	158.02	167.41	171.49
Kerosene inferior	"	152.54	150.57	163.54	168.17
Vaporizing oil	"	162.65	162.65	178.08	180.24
Light diesel oil	"	149.99	154.39	166.23	169.79
Furnace oil	Tonne	76.71	78.36	93.60	96.22
Bitumen straight	"	263.27	253.43	263.27	273.11
Bitumen cutbacks B.S.	"	300.33	290.49	300.33	310.17

* Ex-companies' storage points.

TABLE 6—RATES OF CENTRAL DUTIES OF EXCISE CUSTOMS ON PETROLEUM PRODUCTS (1.1.1964)

Products	Unit	Total duty (Rs.)	
		at 15°	at 29.5°
Motor spirit	Kilolitre	494.85	486.19
Aviation spirit 100/130	"	"	486.29
Aviation spirit 115/145	"	"	485.94
Aviation spirit 73 O.N.	"	"	486.14
Kerosene superior	"	204.27	201.49
Kerosene inferior	"	127.27	125.72
Aviation turbine fuel	"	204.27	201.45
High speed diesel oil	"	455.90	450.38
Vaporizing oil	"	433.90	428.43
Light diesel oil*	Tonne	230.54	196.67
Furnace oil	"	56.15	56.15
Bitumen straight	"	68.43	68.43
Bitumen cutbacks	"	78.43	78.43

* The duty rates at 15° are in Rs./tonne and at 29.5° in Rs./kilolitre.

Before distribution to consumers, natural gas is processed to remove finely divided suspended solids. Next, gasoline (composed of pentanes and heavier hydrocarbons) and liquid petroleum gas (propane and butanes) recovery plants separate the heavier constituents. Finally, hydrogen sulphide and organic sulphur compounds are eliminated to obtain the dry natural gas (mostly methane and ethane) of commerce. A technique has recently been developed to liquefy methane from wells and transport it in tankers to distant places, where it can be reconstituted into town gas before distribution.

As sold to consumers for fuel, natural gas [heating value, 35,000–42,000 B.t.u./cu.m. at 15.6° and 76 cm. Hg; sp. gr. (air=1), 0.56–0.67; explosive limits, 4.8–15] is a colourless gas with a mild odour, similar to that of gasoline. It is often treated, as a safety measure, by the addition of 'odorizing' compounds to make it more readily detectable. Although non-poisonous by itself, uncontrolled leakage of the gas into closed spaces is dangerous to life, because of the displacement of oxygen and the explosive character of the mixture which it forms with air.

The gas-based projects at Naharkatiya are: a thermal power station (installed capacity, 50,400 kW) and fertilizer plant (100,000 tonnes of ammonium

PETROLEUM AND NATURAL GAS

sulphate and 55,000 tonnes of urea/year), and a synthetic rubber plant (capacity, c. 20,000 tonnes/year). Natural gas is being made available for domestic consumption and for the use of small scale industries [Encyclopaedia Britannica, XVI, 163-64; McGraw-Hill Encyclopedia of Science and Technology, IX, 6; ONGC Rep., 1962-63, 1(2 & 3), 43 Kirt & Othmer, VII, 61; Oil Commentary, 1964-65, 2(1), 4; Wlth India—Industrial Products, pt VI, 251-52].

PETROCHEMICALS

Petrochemicals are the primary and intermediate compounds made from the basic hydrocarbons derived from petroleum or natural gas. These hydrocarbons have now become the largest source of organic chemicals. They have undisputed sway in the field of aliphatic chemicals, though derivatives of aromatics are made from both coal tar and petroleum sources. The basic hydrocarbons are processed to produce a large range of products which include synthetic textiles, drugs, solvents, latex paints, rubber, plastics, antifreeze, explosives, detergents, fertilizers and soil conditioners. In U.S.A., about one-third of benzene, three-quarters of toluene and nearly all the xylenes are produced from petroleum sources. The number of intermediate and finished products produced from the hydrocarbons is over 3,000 and is rapidly increasing.

In India, the consumption of chemicals derived from petroleum was estimated to be 15,000 tonnes/year in the beginning of the Third Plan. It is expected to increase to at least 5 times this quantity by the end of the Plan period. The availability of refinery gases and particularly of petroleum naphtha will facilitate the production of nitrogenous fertilizers as envisaged in the Third Plan period. About 0.4 million tonnes of naphtha were available from various refineries during 1962, and this is estimated to go up to 1.0 million or more by 1966. A total investment of Rs. 5,000-6,000 million has been visualized for the establishment of petrochemical industry, starting from basic feedstocks to the distribution of commercial, saleable products.

The Fertilizer Corporation's plant at Trombay is expected to utilize annually 50,000 tonnes of oil refinery gas and 45,000 tonnes of petroleum naphtha from the nearby refineries, to produce 254,000 tonnes of nitrophosphate and 97,500 tonnes of urea/year. The Gorakhpur fertilizer plant will also be based on petroleum naphtha from the Barauni refinery, to produce 180,000 tonnes urea/year. A plant for the

production of methanol essential for the production of drugs, resins, synthetic fibres and dyestuffs is being built by the Fertilizer Corporation at Trombay. It will use synthesis gases produced in the adjacent fertilizer factory. The petrochemical complex being erected in public sector in Gujarat has been divided into naphtha crackers and related projects, and others. Two naphtha crackers are being set up, one near Baroda and the other near Haldia. Production of benzene and toluene will be first undertaken. The petrochemical complex being erected near Thana, Bombay, by Mafat Lal Group in collaboration with Shell International, will process 225,000 tonnes of naphtha from Shell Refinery to produce ethylene, benzene, butadiene, methane, dicyclopentadiene and propylene, which will be utilized for the production of other intermediaries [Purdy, 423-51; Indian Petroleum, 110; Wlth India—Industrial Products, pt VI, 250-51; Oil Commentary, 1963-64, 1(17), 13; 1964-65, 2(1), 55; Chem. Weekly, 1964, 9(12), 5; 1964, 9(9), 23].

PETROSELINUM Hill (*Umbelliferae*)

A genus of aromatic herbs distributed in the temperate regions of the Old World. *P. crispum*, a native of the Mediterranean region, is widely cultivated in Europe and other countries for culinary and ornamental purposes. In India, it is occasionally grown in kitchen gardens, and is the only representative of the genus in the country.

P. crispum (Mill.) Airy-Shaw syn. *P. sativum* Hoffm.; *P. hortense* Hoffm.; *Apium crispum* Mill. PARSLEY

D.E.P., VI(1), 181; Clapham *et al.*, 514; Muenscher & Rice, Pl. 17.

KAN.—*Achu mooda*.

A hardy, aromatic, biennial herb, sometimes lasting up to 4 years, producing a rosette of finely divided radical leaves in the first year and a flowering stalk up to 100 cm. high, in the second. Leaves 2- or 3-pinnate, ultimate segments cuneate-ovate or sometimes linear-oblong, incised, dentate or entire, often much crisped in cultivated plants, upper cauline leaves often ternate; flowers yellow or yellowish green in compound umbels; fruit (commonly known as seeds) 2-3 mm. long, crescent shaped, conspicuously ridged, consisting of two mericarps.

There are two main types of horticultural parsleys: those cultivated for the leaves (convar. *crispum*) and those grown for their turnip-like roots (convar. *radicosum* Danert). Only the former type of parsley is cultivated in India (Mansfeld, 320).

Parsley is a cool weather crop, growing best in a rich moist soil, amenable to deep cultivation. In this country the herb grows better at higher altitudes. Sowing is done in March–May on the hills and August–November in the plains. In European countries, where large scale cultivation is practised, the seed is sown at the rate of 6.8 kg./ha. Germination of the mericarps takes about 15 days or more, but it can be hastened by soaking the seeds in water for a few hours before sowing. Because of the slow rate of germination and tenderness of newly sprouted seedlings, it is preferable to sow the seeds in nursery beds and later transfer the seedlings (5–8 cm.) to the site. In small scale cultivation the seedlings may be planted at intervals of 15–30 cm. in rows 40–60 cm. apart; comparatively narrow spacing is given for seedlings of the turnip-rooted types. Dressing with a nitrogenous fertilizer promotes rapid growth of the seedlings [Talbert, 255; Chittenden, III, 1487; Gopalaswamiengar, 561; Lowman, *Fmrs' Bull., U.S. Dep. Agric.*, No. 1977, 1946, 18; *Bull. Minist. Agric., Lond.*, No. 76, 1951, 11; Guenther, IV, 661; Knott, 225; Krishna & Badhwar, *J. sci. industr. Res.*, 1953, 12A(2), suppl., 282; Beattie, *Leafl. U.S. Dep. Agric.*, No. 136, 1937, 1].

The leaves are ready for harvesting in about three months. The outer larger leaves are periodically cut off for several weeks. In commercial plantations a hectare of land yields c. 2,500 dozen bunches at each cutting, and 2–5 cuttings are possible for each planting. Harvesting period can be considerably prolonged by preventing the plants from flowering. The roots of the turnip-rooted variety are usually dug out after the fruits have been harvested; they are frost-resistant, but repeated freezing makes them pithy. The thick roots are cut longitudinally to facilitate drying. The fruits are collected for extraction of parsley oil of commerce. In France, a hectare of land is said to yield 800–1,500 kg. of fruit (Knott, 225; *Bull. Minist. Agric., Lond.*, No. 76, 1951, 11; Sievers, *Fmrs' Bull., U.S. Dep. Agric.*, No. 1999, 1948, 75; Beattie, loc. cit.; Youngken, 632; Guenther, IV, 661, 657).

Fresh leaves mask even strong culinary odours and are commonly used for garnishing and seasoning; they are eaten fresh, incorporated in salads, and used as an ingredient of soups, stews and sauces. The leaves are also employed to make a sort of tea which is considered to possess antiscorbutic properties. The roots are used as a vegetable in soups. The dried leaves and roots are used as condiments, but the use of fruits for this purpose has been contradicted by some

authors. The fresh leaves are a good source of iron, calcium, carotene and ascorbic acid. Analysis of the green leaves gave the following values: moisture, 68.4; protein, 5.9; fat, 1.0; carbohydrates, 19.7; fibre, 1.8; and mineral matter, 3.2%; calcium, 390 mg.; phosphorus, 200 mg.; iron, 17.9 mg.; carotene (as vitamin A), 3,200 I.U.; thiamine, 0.04 mg.; nicotinic acid, 0.5 mg.; and ascorbic acid, 281 mg./100 g. The vitamin A content ranges to as high as 8,230 I.U./100 g.; riboflavin and biotin are also present. The leaves, stems and fruits contain a glucoside apioin which on hydrolysis yields apigenin (5, 7, 4-trihydroxyflavone, $C_{15}H_{10}O_5$, m.p. 347–48°), glucose and a sugar apiose ($C_6H_{10}O_5$); a second glucoside, consisting of luteolin, glucose and apiose has also been reported. The fruits of plants from Delhi yielded 2.2% of apioin, but the second glucoside could not be detected (Lowman, *Fmrs' Bull., U.S. Dep. Agric.*, No. 1977, 1946, 18; Muenscher & Rice, 73–74; Parry, J. W., 1962, 205; *Hlth Bull.*, No. 23, 1956, 34; Watt & Merrill, *Agric. Handb. U.S. Dep. Agric.*, No. 8, 1950, 37; *Chem. Abstr.*, 1953, 47, 5575; Nordstrom et al., *Chem. & Ind.*, 1953, 85; Gupta & Seshadri, *Proc. Indian Acad. Sci.*, 1952, 35A, 242; Heilbron & Bunbury, I, 198–99).

The herb is reported to possess diuretic, carminative, ecbolic, emmenagogue and antipyretic properties, and has long been in use for uterine troubles. The juice of the fresh leaves is used as an insecticide. Parsley causes skin reactions in some people, and this is attributed to the presence of a furocoumarin, bergapten. Bruised leaves are applied to bites and stings of insects, and the mericarps are used to get rid of lice and skin parasites. Extracts and infusions of leaves and roots on subcutaneous administration in mice produced a depressing effect on the nervous system. In a series of experiments conducted on heart of frogs, cats and rabbits, it was noted that small doses (2 drops) of 1% aqueous infusion of leaves increased the amplitude and slowed cardiac contraction; large doses (5–10 drops) of 10% leaf infusion were followed by depression of cardiac activity. Intravenous administration of the infusion as well as the extract caused fall in blood pressure and dilatation of the blood vessels (Hocking, 167; Tehon, 86; Hoppe, 656; *Chem. Abstr.*, 1955, 49, 7188; Jacobs & Burlage, 217; *Biol. Abstr.*, 1960, 35, 3437).

All parts of the plant contain an essential oil, Oil of Parsley, which is responsible for the characteristic aroma and flavour of parsley. The oil is recovered by steam-distillation and is used mainly for flavouring

TABLE I—CHARACTERISTICS OF ESSENTIAL OILS FROM
*P. CRISPUM**

	Fruit oil	Herb oil
sp. gr. ^{15.5°}	1.043–1.110	0.902–1.016
[η] _D	-4° to -10°	+1.27° to +4.17°
$n^{20^{\circ}}$	1.512–1.528	1.509–1.526
Acid val.	up to 6	up to 1
Ester val.	1.11	5.14
Ester val. after acetylation	4.20	19–68
Solubility	1.8 vol. and more of 80% alcohol, in exceptional cases with turbidity	in 95% alcohol

* Guenther, IV, 657, 659–60.

food products. The oil obtained from the flowering tops is of the finest quality, truly representing the odour of the leaves, but the yield is too low (0.06%) for commercial production. Commercial parsley oil is distilled either from the aerial parts of the herb bearing immature fruits (Herb Oil, yield c. 0.25%) or from the mature fruits (Fruit Oil, yield up to 7%). The herb oil possesses a superior aroma and is more esteemed than the fruit oil. The characteristics of the herb and fruit oils are given in Table I (Guenther, IV, 656–59, 663).

The fruit oil contains apiole (Parsley Camphor) and α -pinene, with small amounts of myristicin, aldehydes, ketones and phenols. The herb oil is reported to contain apiole but no detailed investigation appears to have been undertaken. The apiole is used medicinally for the same purposes as the herb, but is of doubtful therapeutic value. Commercial apiole is frequently adulterated with tri- α -cresyl phosphate, which may cause severe toxic effects (Krishna & Badhwar, loc. cit.; Martindale, I, 1358; Chopra *et al.*, 513).

The fruits yield c. 20% of a greenish fatty oil, with a peculiar odour and disagreeable sharp flavour. The oil has a high content of petroselinic acid (up to 76%). It can be tried for a variety of industrial purposes, such as making of plastics, synthetic rubber, lubricating oil additives and protective coatings [Jamieson, 245–46; *Agric. Res., Wash.*, 1962–63, 11(7), 8].

PETUNGA DC. (*Rubiaceae*)

Fl. Br. Ind., III, 120.

A genus of shrubs or small trees distributed in the Indo-Malaysian region. One species occurs in India.

P. roxburghii DC. (BENG.—*Pitanga, jhijir, narkeli*) is a handsome shrub or a small tree with light brown bark, oblong-lanceolate leaves and small, ovoid,

orange-yellow berries, found in the Sunderbans. The wood (wt., 577 kg./cu. m.) is greyish white, close- and even-grained and moderately hard. It is reported to be used for boxes and rough furniture (Gamble, 417; Rodger, 38).

PEUCEDANUM Linn. (*Umbelliferae*)

A genus of herbs, shrubs and rarely trees distributed chiefly in Europe, Asia, North-East Africa and western South America. Ten species occur in India.

P. grande C.B. Clarke

D.E.P., VI (1), 181; Fl. Br. Ind., II, 710; Kirt. & Basu, Pl. 484A.

HINDI—*Duku*.

BOMBAY—*Baphali*.

A succulent herb, about a metre or more in height, occurring gregariously on the western ghats and the hills of Deccan plateau. Roots large, perennial; stem fistular, emitting a strong scent on crushing; leaves pinnate or bipinnate, mostly radical; flowers yellow in compound umbels; fruits (mericarps) obovate or broadly elliptical, 10–13 mm. long, narrowly winged, reddish yellow.

The fruits have a powerful lemon-like odour and are used in medicine, and as a condiment. They possess carminative, diuretic, stimulant and tonic properties and are given in the form of an infusion in gastric and intestinal troubles. Commercial drug is not infrequently substituted by other umbelliferous fruits (Dymock, Warden & Hooper, II, 127; Kirt. & Basu, II, 1221; Nadkarni, I, 935).

The fruits yield a small quantity (c. 1.5%) of a light yellow essential oil (sp. gr.^{15.5°}, 0.900; [η]_D, +36°) having a strong odour of carrot oil (Gildemeister & Hoffmann, VI, 508).

P. dhana Buch.-Ham. ex C.B. Clarke var. *dalzellii* C. B. Clarke (BIHAR—*Bhoj raj, mann tiro*; BOMBAY—*Koland*), a perennial herb with yellow flowers, is found in Maharashtra, Bihar, Orissa and Andhra Pradesh. The roots taste like carrots, and are eaten as a tonic and febrifuge. *P. nagpurensis* Prain syn. *P. glaucum* var. *nagpurensis* C. B. Clarke (BENG.—*Tej raj*; ORIYA—*Epondom, trio-singhi*; MUNDARI—*Bir samraj, turi, epelom*) is a herb with greenish or brownish flowers, found in parts of Bihar, Orissa and West Bengal. Its fistular stems are employed for making flutes, and the roots are used as a stomachic (Cooke, I, 569; Kirt. & Basu, II, 1222; Bressers, 71; Haines, III, 413).

Peucedanum spp.—see *Anethum, Pastinaca*

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Tumoh (Assam)	..	10	<i>Varagi</i> (Tam. & Mal.)	..	270			
Tungprung (N. Bengal & Lepcha)	192		<i>Varai</i> (Guj.)	..	225	<i>Yedalei</i> (Tamil.)	..	91
Tiorusi (Mundari)	..	87	<i>Varidhanamu</i> (Tel.)	..	115	<i>Yerrajavvi</i> (Tel.)	..	76
Turi (Mundari)	..	330	<i>Variga</i> (Tel.)	..	225	<i>Yerwa</i> (Bombay)	..	99
TURPETH	..	97	<i>Varo</i> (Mar.)	..	225	<i>Yongchak</i> (Assam)	..	265
			<i>Varvara</i> (Sans.)	..	81	<i>Yugma thalika</i> (Sans.)	..	309
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<i>Udagaddi</i> (Tel.)	..	268	<i>Veliparatti</i> (Tam. & Mal.)	..	310	<i>Zemaro</i> (N.W. Himalayas)	..	268
<i>Ud-salap</i> (Hindi)	..	211	<i>Vellambal</i> (Tam.)	..	71	<i>Zolaomil</i> (Nepal)	..	198
<i>Ukada tandul</i> (Mar.)	..	168	<i>Veludupachha</i> (Tel.)	..	81	<i>Zongto</i> (Assam)	..	265
<i>Ulagera</i> (Kan.)	..	67	<i>Vilayati babul</i> (Hindi)	..	265	<i>Zufa yabis</i> (Punjab)	..	12
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